ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND B. ALFRED RAWORTH.

VOL. CIV.—FROM JULY TO DECEMBER, 1917.

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SESSION 1917-1918.

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W. M. GIBBONS, Registrar.

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School of Technology (UNIVERSITY OF MANCHESTER).

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THE TEXTILE INDUSTRIES,
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MINING,
ARCHITECTURE.

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TALFOURD STRICK,
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Harbour Offices, Swansea,
30th June, 1917. H 151

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LECTURER IN ENGINEERING, RUTHERFORD TECHNICAL COLLEGE.

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22nd June, 1917. H 97

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H 87

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has VACANCIES for several DRAUGHTSMEN. Previous experience of aeroplanes not essential. No one already engaged on Government work or resident more than ten miles away need apply. State age, experience and salary.—165, SELL'S Advertising Offices, Fleet Street, E.C. 4. H 110

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WANTED at once on urgent Aero Engine Work. Must have had experience on tool work. Good pay and bonus. Detailers also wanted. None on Government work will be considered.—Apply at your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 3328. H 109

Jigmakers and Cutter Filers.

—Three of each REQUIRED by a Company engaged on important War munitions. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A3377. H 168

Wanted, Draughtsman for

the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2031. G 457

Draughtsman Wanted, thoroughly

capable, for large blast furnaces and steel works plant. State age, experience, salary required, and when at liberty. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 3295. G 996

Required, Immediately, for

Controlled Engineering Works, S.E. London,
DRAUGHTSMAN (Mechanical or Marine).
Ditto (with knowledge of Estimating Weights of Castings).
DRAWING OFFICE CLERKS (one Male, one Female).

Junior applicants must have had several years' experience. No applicants residing outside radius of ten miles or already employed on Government work can be engaged.—Address, stating age, experience and salary required, H 101, Offices of ENGINEERING.

Wanted, Several First-class

Mechanical DRAUGHTSMEN, with good all-round experience, for Admiralty work.—Apply (by letter only), stating age, experience, and present salary to BOX No. 1155, care of Messrs. F. F. WHITE & SON, Genl. Advng. Agents, 83, Fleet Street, E.C. 4. H 122

Draughtsman (Marine)

WANTED for East of Scotland, with experience in construction of small marine and auxiliary engines. No person already on Government work can be engaged without consent of present employer.—State age, experience, and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and H 187.

Draughtsman Wanted,

accustomed to envelope machines. Apply, stating age, experience, salary expected, and position regarding Military or National service. No one employed on Government work will be engaged. —Apply to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 172.

Draughtsmen.—Some Experience

in crane work essential. Both Junior and Senior men REQUIRED, London district. Applicants must state age, past experience and salary required. No person at present employed on war work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 150.

Draughtsman, with General

experience REQUIRED for mechanical engineer's office in large Munition factory at Coventry.—State experience, age and salary required to your nearest EMPLOYMENT EXCHANGE, quoting A 3147. No person already on Government work will be engaged. H 158

ENGINEERING.

RESCUE APPARATUS IN MINES.

To reduce the loss of life arising from explosions in mines and to give additional security to those who run risks in encountering noxious fumes and gases is a problem that commands the ready sympathy of all. Every Government has encouraged inquiry directed to furnishing remedial measures, and many have promoted legislation to ensure more adequate protection. The Government of the United States, though only of late vigorously bestirring itself in the general problem, has shown by the report* recently issued under the authority of the Director of the Mining Bureau (Mr. Van H. Manning) that this department is disposed to deal energetically and on well-considered lines with a baffling and difficult situation.

Progress towards providing the most suitable apparatus demands the association of the physiologist and the engineer, the former to determine the amount and character of the air required under any circumstances in which the rescuer may be placed and to afford him every possible assistance under abnormal conditions: the latter to invent or construct the mechanical devices that will fulfil the requirements upon which the physiologist insists. In this report two such experts have co-operated. Dr. Henderson has had much experience with breathing apparatus as used in physical laboratories; Mr. Paul is a mining engineer who has had charge of the training corps for rescue and recovery work connected with the Bureau of Mining. It may be mentioned here that these authorities have had the practical assistance of Mr. W. E. Gibbs, a mechanical engineer of experience and skill, who, with his staff, has been able to effect such improvements in the trial apparatus as were suggested in the course of the inquiry, so that theory and practice went hand in hand. These improvements or alterations have been embodied in a complete dress, at present under further trial, but which, if found satisfactory, will be put on the market under the authoritative sanction of the Bureau. It will be gathered, therefore, that the report is entitled to careful consideration, and it is to be hoped that the deliberate decisions recorded will have their due weight with the public. For the employment of breathing apparatus is coming largely into vogue, finding applications in novel ways and facilitating work where ventilation is defective, or where of necessity noxious chemical gases are prevalent. Intending purchasers need a guide, being liable to be misled by ignorance or by fashion, and it is most desirable to discourage the sale of an indifferent or bad type. The opinion of the experienced wearer is a most unsafe guide, for, as the authors remark, use seems to give confidence, defects are reluctantly admitted, and improvements banned. An apt illustration is found in the partiality for the helmet. This piece of apparatus has many defects, as we shall point out presently, and has proved a death-trap in well-marked instances. But the helmet is dear to popular imagination, it gives dignity to the wearer and looks well in the photograph. Moreover, it is the symbol and badge of the dangerous and sacrificing work undertaken, and the owner is unwilling to forgo the respect and admiration it inspires. The makers of the helmet know its disadvantages, but as the authors were informed by the agent of one of the largest supply companies, "their customers will have helmets, and if he did not supply them, they would obtain the apparatus so equipped from his competitors." Hence the necessity for a more intelligent appreciation by the public of the requirements of rescue apparatus and of the principles underlying its construction.

Looking at what the apparatus has to effect and the limited means by which its purpose can be accomplished, it will be easily understood that the fundamental principles of design admit of little variation. The main object is to furnish air in sufficient quantities, and with due mixture of oxygen, to enable a person to breathe when exposed to an irrespirable atmosphere, while at the same time excluding the possibility of inhaling the poisonous surrounding gases. The time factor is of the essence of the problem. If protection were needed for only a few minutes it would be possible to utilise compressed or liquid air, but apart from the difficulty of keeping a supply of liquid air for any length of time, the weight of the air and of suitable holders of sufficient capacity to furnish entirely fresh air at each breath makes such a simple but ideal method impracticable. Recourse must be had to rebreathing the same air many times. This is clearly demonstrated if the quantity of air or of oxygen required by a man making vigorous physical exertion is correctly apprehended. While resting, a man breathes some seven litres of air and uses 300 c.c. of oxygen per minute, but in performing hard manual labour, as may be occasionally required, he may use as much as 140 litres of air and 3,000 c.c. of oxygen. It is necessary to contemplate the task of maintaining a rescue party in the midst of a deleterious atmosphere for two hours uninterruptedly, and if we multiply these numbers by 120, it will be clear that the only possible arrangement of apparatus is one that permits a man to rebreathe, from the same source of supply, an atmosphere in which the oxygen is replaced as it is consumed, and the carbon dioxide absorbed as it is exhaled. Other suggestions attractive in theory have been made, but not having stood the practical test of long endurance do not come under consideration here. Of such is the delightful prospect of utilising some material, such as sodium or potassium peroxide, that should serve both as the source of oxygen and the absorber of CO_2 exhaled. In this particular instance the heat evolved in liberating oxygen from sodium peroxide is an additional objection.

The evil name attaching to carbon dioxide has been much exaggerated. It is no longer regarded with the extreme dread it once excited. We are more tolerant of the quantity of the gas that can be present in the atmosphere, knowing the extent of the injury it can occasion. The sanitarian used to insist on the importance of keeping the CO_2 content below 0.1 per cent. His was a counsel of perfection, impossible of attainment: the fact was overlooked that no one breathes pure outside air into his lungs; at each breath is drawn through the nose and large air tubes air heavily charged with the poison, and it is now admitted that the only result of breathing air containing 0.5 per cent. to 1 per cent. of the gas is an inappreciable increase in the ventilation of the lungs. The effort to keep the carbon dioxide within small limits is not so much to ensure the safety or comfort of the worker, as to provide for his efficiency. The point to be borne in mind, not only in extreme cases which make a breathing apparatus necessary, but as an ever-present rule affecting the respiratory system, is that the organs controlling the breathing are acutely responsive to minute variations of carbon dioxide. The man who, when working, requires more oxygen than at rest, also produces more CO_2, a waste product that, on being carried to the respiratory centre, excites a nicely adjusted increase of breathing, so that the excess of CO_2 is thrown off and the needed amount of oxygen absorbed. This does not imply that the effort to bring about a compensation entails no evil consequences. A small amount of CO_2 induces panting (dyspnœa), and if the amount approaches 3 per cent. the panting induced by this vitiated air, added to the effect of exertion, becomes painfully apparent. When 5 per cent. of CO_2 is present the effort to breathe submits the muscles of the chest to a great strain, and the effort to breathe exhausts the subject; any exertion becomes impossible. The impression on the mind of anyone submitted to such an excess of CO_2 is similar to that which would arise from inability to draw sufficient air into the lungs, and when fitted with a breathing apparatus the wearer imagines, mistakenly, that the trouble arises from the circulating system being blocked, a belief so terrifying and unfortunate that even one trained and experienced cannot resist the temptation to tear off the apparatus—even in the midst of deadly gases.

The effects attributable to a deficient supply of

* "Oxygen Mine Rescue Apparatus and Physiological Effects on Users." By Yandell Henderson and James W. Paul. Washington Government Printing Office, 1917. For gratuitous distribution.

oxygen are quite as dangerous and more insidious than those induced by excess of carbon dioxide. The symptoms resemble those of alcoholic intoxication, especially in the temporary loss of discretion and judgment. There is no noticeable increase in the rate or depth of breathing, and the subject who voluntarily submits himself to experiment is unconscious of any pain or discomfort. Although on the verge of collapse, he will still wish the experiment to be continued. If the deprivation of oxygen is severe, that is reduced to about half the normal amount, headache and unconsciousness usually supervene, the distressing symptoms lasting much longer than when occasioned by carbon dioxide. The delicate cells of the nervous system can be permanently injured, and in this respect the sequelæ are much more akin to those following carbon monoxide poisoning, as a protection against whose deadly effects the rescue apparatus has been designed and is mainly used. This gas, a constituent of after-damp, is odourless and has no irritant effect, either immediately or subsequently, upon the lungs. It might be described as inert but for its avidity for hæmoglobin, with which it combines in the same way as oxygen, but with a vigour approximately 250 times as strong.

Before quitting the physiological aspect we may call attention to the pertinent cautions that the authors urge concerning the use and abuse of methods of artificial respiration. The temptation to use such treatment when opportunity arises seems in many cases too strong to be resisted. But neither manual nor mechanical methods should be resorted to if the patient is capable of breathing effectively. Unconsciousness is not sufficient grounds for applying such remedies. Spontaneous respiration should have stopped, or become irregular, before these methods find a fit field of usefulness. When imperatively necessary, time is an important factor in the choice of appropriate means. The prone pressure, or Schaefer, method is here seen to advantage. For in principle it accomplishes all that any apparatus is competent to do, only in volume of artificial respiration does it fall below some of the devices on the market. This defect is amply compensated by its readiness of application. The heart will be asphyxiated and stop beating within 8 or 10 minutes after oxygen ceases to be absorbed from the air of the lungs into the blood. Whatever has to be done must be done in those few minutes, for after the heart has stopped entirely no form of artificial respiration will make it recommence. The delay occasioned by the knowledge that apparatus is available and "has been sent for" is responsible for many fatalities. As a measure of precaution the authors recommend that where a pump is used to force air into the lungs a blow-off valve operating at 25 cm. water gauge should be provided, and when used to withdraw air from the lungs an inlet valve set at a negative pressure of 15 cm. Knowing the eager excitement that usually prevails when these instruments are used, such provision seems salutary.

The examination of the physiological principles that have to be observed in the construction of an efficient breathing apparatus will suggest the lines the mechanical arrangement must follow. Indeed, the conditions are so narrowly circumscribed that ingenuity finds little opportunity for generic variation, and possible improvements on the original model are restricted to details. Even in this limited field it is not infrequently found that a real or apparent improvement in one direction is counterbalanced by some disadvantage that is inevitably introduced in another. Fixing attention on bare essentials, it will be seen that these consist of a rubber bag or bags into which the wearer breathes, and from which he gets a supply of air: a steel cylinder containing compressed oxygen, which feeds into the bag through a convenient valve; and the provision of sodium hydrate or some similar alkali, so placed as to absorb the carbon dioxide exhaled. Armed with these the rescuer may be safe, but their proper distribution about the body, due precautions for preventing any mechanical obstruction in the tubes, the certain prevention of any leakage of the poisonous gases into the apparatus, and thence to the lungs, are indispensable details that will lighten the task and add not a little to safety. The general design that meets practical demands is well illustrated by the form adopted in the Fleuss apparatus. Others, as the Draeger and the Westfalia, are on the market, but present no new principle, their main features differing but little from the Fleuss, whose method of operation can be followed from the diagram shown in Fig. 1. The arrangement of the several parts of the dress as worn will be understood from Figs. 2 and 3, which are front and back views respectively.

Two cylinders of compressed oxygen are slung over the back, and a reducing valve in connection with these permits a uniform flow of oxygen of about 1,800 c.c. per minute. As we have seen, such a rate of supply corresponds with the mean consumption between rest and energetic work; the rate may prove wasteful in one case and insufficient in the other. There is, however, a by-pass controlled by a separate stopcock by which the large rubber breathing bag can be rapidly inflated. The tube for carrying the oxygen supply passes under the wearer's arm to the bag suspended over the chest and abdomen, while other flexible tubes lead from the upper corners of the bag to the mouthpiece. Valves are placed at the junctions of the tube with the bag, causing the wearer to inhale from one side and exhale from the other, an operation that is assisted by a partition of heavy sheet rubber placed in the bag, reaching nearly to the bottom. To ensure breathing being confined to the mouth, a nose clip compresses the nostrils.

The supply of caustic soda carried is regulated by the oxygen content in the cylinders, usually about 4 lb. to 6 lb. in stick form will be sufficient. It is easily seen that carbon dioxide should be absorbed and that an adequate supply of oxygen should flow in from the reducing valve. Practically the working is not so simple as the description suggests. It is found necessary to shake the bag repeatedly in order to knock off the accumulated carbonate formed on the sticks and keep exposed a quick-acting surface. A more serious matter is the heat evolved by the chemical reaction. The entire mass of caustic soda may become so hot that the water from the carbonate is driven off. Then the air inhaled becomes saturated with moisture at a temperature higher than that of the body—140 deg. F. is not unusual—and the moisture condenses in the mouth and throat, giving off its latent heat. The evaporation of alcohol held in a cloth and acting as a saliva trap is under such circumstances utterly inadequate as a cooling device. The Fleuss apparatus can be arranged to carry a supply of sodium sulphate, a crystalline substance that liquefies at about 90 deg. F. with considerable absorption of heat. Instead of reducing the temperature by absorption, the preferable method is to prevent the production.

Deviations from the Fleuss type, exhibiting conflicting advantages and disadvantages, are many, but there is no generic departure in principle. In the Draeger and Westfalia types the absorber of carbon dioxide is not placed in the breathing bag, but is contained in a cartridge of sheet metal in which granules of alkali are carried on small trays or upon wire gauze. This promises an improvement, as the surface exposed is greater for the same weight, but the metal becomes so hot that it cannot be touched with the hand. The passage of air through the cartridge is effected by means of an injector through which the oxygen feeds into the tubes and breathing bag. The authors' tests and experience point to the advantages of maintaining a natural circulation,

Fig. 1 CIRCULATING SYSTEM OF FLEUSS. OR PROTO. APPARATUS.

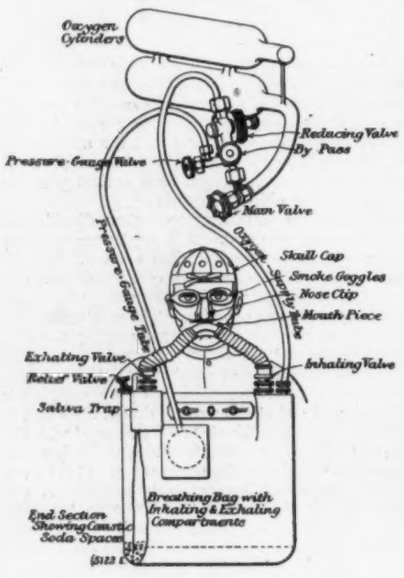


FIG. 2.

FIG. 3.

since the inspiration bag is liable to be emptied when from any cause, as violent exertion, the rate of breathing exceeds the automatic circulation, bringing about that feeling of suffocation that tempts the best trained to commit some desperate act by way of remedy.

The feature, however, against which the authors express their strongest disapproval is the helmet, a frequent accompaniment of all types, but inseparable from the Draeger and Westfalia. The disfavour is shared by many authorities, as Dr. J. Haldane, under whose direction the London Fire Brigade has discarded its use. The serious objections to this headgear are based on two grounds; first that it gives opportunity for a dangerous leakage of deadly gases through cracks, crevices and loose joints of the apparatus, and secondly that it necessitates the wearer's breathing into a "dead space" in such a way that he re-inhales the foul air that he expires into it. The air in this confined space, usually about 2,400 c.c., contains from 2 per cent. to 3 per cent. more carbon dioxide than that in the bag. Headache and a mild form of CO_2 intoxication are the usual consequences of prolonged submission to this pernicious method, but the admirers of the helmet attribute these symptoms to the tightness of the ligature round the temples. The authors' tests seem to be conclusive. The opportunities for leakage are many and apparent, for the "human face is a peculiarly difficult object upon which to make an accurate fit." When the rubber ring or cushion, which is inflated to fill the space between the edges of the helmet and the face, and is bound so tightly as to make deep grooves in the skin of the face, is in position, small irregular openings may and do prove a source of danger. A man will collapse who has inhaled only 400 c.c. to 600 c.c. of carbon monoxide, and a much smaller quantity will render him incapable of exertion and deprive him of clear judgment. With a poison so deadly and so insidious we can afford to take no risks. Even the simpler mouthpiece becomes a source of suspicion. Complete tightness at all times is difficult to ensure. By merely retracting the corners of the lips it may be possible to create a sufficiently large opening at each end, through which outside air can be drawn in. The flange should be so made that it can be adjusted to the size and shape of the wearer's mouth.

The authors would have rendered a valuable service if they had simply tested apparatus by different makers and called attention to the merits and defects of each. But they have done more than this. They have endeavoured with the aid of Mr. Gibbs to incorporate into one dress the advantages of all, while excluding the deficiencies of each. Such a task was perhaps impossible, because, as we have pointed out, compromise must finally be made in respect of the several requirements. Their aim to combine the results of scientific investigation with inventive skill is praiseworthy, to pay regard to the physiological requirements of the wearer and the judgment of mining men is eminently practical. Above all they have submitted each device as it has been completed to severe trial, in order to test its durability and efficiency. The result is the combination shown in Figs. 4, 5 and 6, the first-named illustration giving a diagrammatic view of the assembled parts. The points upon which attention has been more particularly fixed are the control of the oxygen supply, replacing the fixed feed valve by a self-adjusting arrangement. The wearer of the apparatus breathes into, and from, a small bellows. When the bellows is sucked flat a valve is opened which allows oxygen to feed in rapidly from the compression tank through a reducing valve. The object is to adjust the rate of oxygen supply to the breathing, so as to ensure sufficient oxygen under all conditions of exertion, and by preventing waste make the limited quantity last as long as possible. The alkali absorbent is also differently arranged: the aim being to keep the carbon dioxide in the circulating system below 1 per cent. The sodium hydroxide is cast in plates upon wire gauze and in quantity sufficient to fix 2½ litres of CO_2 per minute. The distinguishing feature, however, is an apparently successful attempt to use an alkali containing a small percentage of water of crystallisation, approximately one molecule of water to two of sodium hydrate. The avidity of the alkali for moisture is thus partly satisfied, so that the amount of heat is reduced and the alkali is efficient at a much lower temperature. The efficiency of the absorption is shown by the diagram in Fig. 7, which at the same time illustrates the cumulative effect of carbon dioxide under the stress of exertion and the beneficial effects of frequent rests. The diagram exhibits the percentage of CO_2 in the air of the bellows of the apparatus throughout a two hours' endurance test, "in which the wearer walked 15 minutes at 3 miles an hour, 7 minutes at 4 miles, ran 3 minutes at 5 miles and rested 5 minutes, repeating this cycle every 30 minutes." In estimating the endurance the weight of the apparatus, about 35 lb., should be taken into account. In another test the absorber retained a useful efficiency for 140 minutes. Moreover, while the temperature of the inspired air remained "cool," that of the Fleuss apparatus in the same trial reached 134 deg. F. Another important point on which the authors insist is an increase in the diameter of the tubes, so as to permit the breathing of 100 litres of air per minute without undue resistance. This requirement has been recognised by the London Fire Brigade, who insist that the Fleuss apparatus shall be fitted with tubing 2.5 cm. internal diameter; the valves being correspondingly increased. Many smaller precautions are recommended to prevent compression of tubes or bags from accidental closing of valves, and damage to apparatus when travelling through tunnels or amid obstructions.

When all precautions have been taken it must not be forgotten that the man who puts on a breathing apparatus to fight against deleterious gases takes his life in his hand. Its limitations are many and evident, and he sets out to fight a foe who plays the game fairly, but inexorably. Courage and the laudable desire to save life have no weight against the merciless exercise of unyielding laws. Very restricted, therefore, are the possibilities of the protected miner on his errand of mercy. If he can walk erect he may not, with safety, penetrate more than 2,000 ft. from pure air. In crouching through tunnels, perhaps 4 ft. high, his pathway should be strictly limited to 500 ft., and as obstruction becomes greater and more exertion is demanded, 200 ft. to 300 ft. may be considered the maximum distance beyond fresh air to which the crew should attempt to penetrate. Let it be considered what it means if one of the party is injured by accident or becomes

Fig. 4. CIRCULATING SYSTEM OF GIBBS BREATHING APPARATUS.

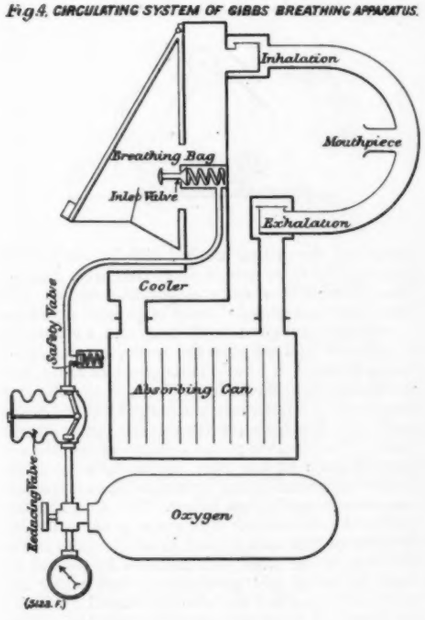


FIG. 5.

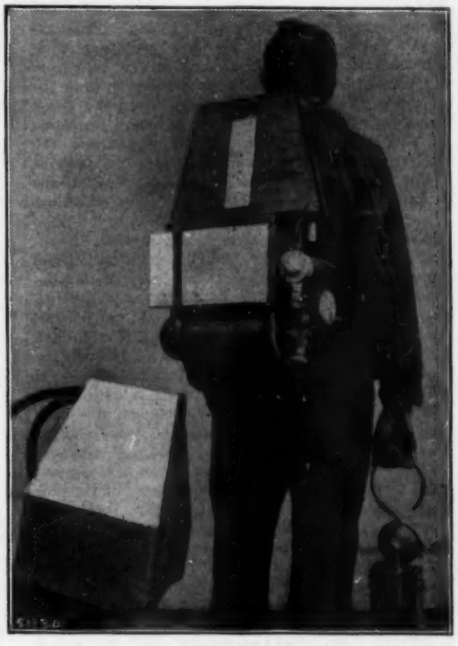
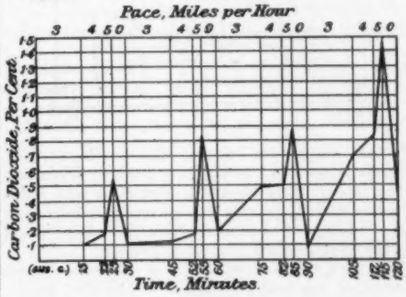


FIG. 6.

CURVES SHOWING EFFICIENCY OF CARBON DIOXIDE ABSORPTION IN THE GIBBS APPARATUS AT VARIOUS RATES OF WALKING
Fig. 7.



distressed and has to be assisted back to safety. In the great majority of cases neglect of the limitations proposed, due to a regrettable excess of zeal, rarely fails to add to the loss of life.

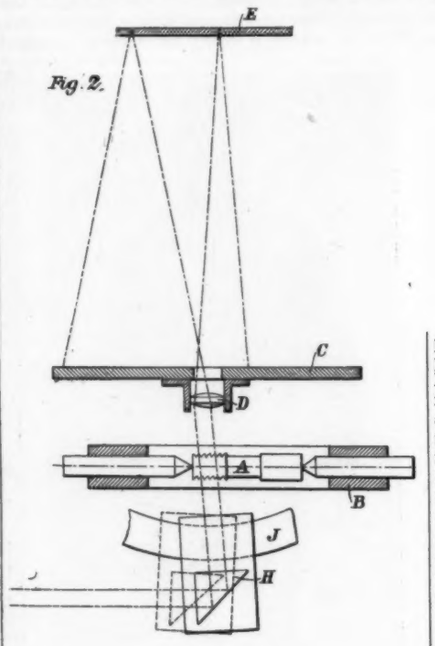
THE NATIONAL PHYSICAL LABORATORY IN 1916–17.

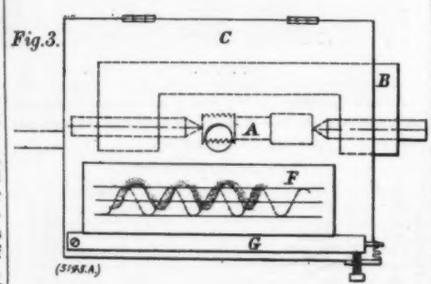
(*Continued from page* 624 *of volume* ciii.)

Metrology. (Mr. J. E. Sears, Junr., M.A., A.M.I.E.E.; Messrs. S. W. Attwell, N. L. P. Jolly, E. A. Owen (on active service), E. G. Constable, F. H. Rolt, F. A. Gould, V. Stott, B. P. Dudding, J. H. Hyde, H. A. Dear, E. M. Eden, A. J. C. Brookes, &c.; a staff of 43 members, including five women.)—We have already dwelt on the heavy load of work which the Ministry of Munitions put on the Metrology Division. There was, further, a recovery in other branches of test work which the war had adversely affected in the first year; this was notable in the case of aneroids, of which over 900 were tested in the three steady-temperature rooms, and of chemical weights (1,784). The total number of tests made by the department (excluding special work for the Munitions Ministry) rose from 8,214 to 11,687. Hardly less noteworthy than the official work are the successful efforts by the division to assist the manufacturers, especially gauge makers, in checking their work and in explaining the difficulties of measurements to them; we describe below some of the novel machines devised in the Laboratory for this purpose, drawings of which are placed at the disposal of the manufacturers, none of the machines being patented. A pamphlet, "Notes on Screw Gauges," is in course of revision; it will contain all such information regarding the new devices as can conveniently be published at present. These various duties severely taxed the capacity of the staff and of the buildings. The staff was much strengthened. A small temporary extension to the metrology building, comprising drawing offices and workshops, was made last summer; a building of 150 ft. by 40 ft., partly of two storeys, was then erected, but this building was not ready for occupation before the end of May, 1917. Meanwhile, accommodation had to be found in the optical building and elsewhere. The equipment of the new workshops comprises machines by Messrs. Brown and Sharp (universal miller, surface grinder), by Messrs. Pratt and Whitney (tool-room lathes, bench lathe, sensitive drill), and a Churchill universal grinder. The workshops have proved very valuable in producing small accessories for testing gauges and for developing the new test methods referred to, benefiting both the Laboratory and the gauge makers. The standard lathe has again seen service during the past year, several master lead screws having been sent in for correction of pitch; this work was carried out by the engineering department, and the lathe itself has been recalibrated, with satisfactory results. Difficulties encountered in connection with screw-gauge work during the war had led to the reconstruction of the various screw-gauge committees of the Engineering Standards Committee, which, under the chairmanship of Colonel Crompton (succeeding the late Sir H. F. Donaldson), have taken up the reconsideration of tolerance and thread form. That will involve a great deal of experimental work in the coming year and further restrict the time that might possibly be devoted to research. Mr. Sears must feel it very hard that researches such as the observation of the secular changes in the 50-m. base had also to be discontinued during this winter, the exceptional severity of which would have rendered the continuous records particularly valuable.

As regards physical tests, the new standard hydrometers calibrated during the year much accelerate this work. The demand for tests of other glassware has not grown much so far, but the Glass Manufacturers' Association is considering the much-needed testing of graduated apparatus.

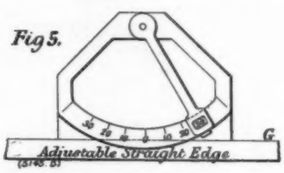
Watches and Marine Chronometers. (Mr. Constable.)—The numbers of watches entered this and last year for examination were respectively 340 and 379, of chronometers 118 and 84. The number of English watches presented for class A certificates was 97 and 112, the falling-off being due to the war; the subsidiary A class of chronograph watches has diminished with the cessation of sports; of the 97 sent, 31 failed. This looks a high figure, but the tests are severe; 47 class A watches were awarded the distinction "especially good," and the number of watches which obtained 90 marks and upwards is high, being only lower than the 1913 record, when 37 (out of 257 watches) secured that certificate. As regards the 47 "especially good" watches the first place was again taken by Messrs. Vacheron and Constantin, of Geneva, with their keyless double-roller going barrel bar movement (95.2 marks); several other Swiss firms compete with this Geneva firm in the first places, the London firm of Messrs. C. Frodsham and Co. occupying the twentieth place (with 92.4 marks). The number of marine chronometers sent increased from 84 to 118; of these 32 failed, this figure being slightly above the average; the main cause of failure was acceleration of the daily rate during the 55 days' trial. Admiralty tests of this kind are made at Greenwich Observatory. One electric master clock and seven impulse dials (receiving the current impulses from the pendulum of the master clock) have been tested for the Synchronome Company, London.





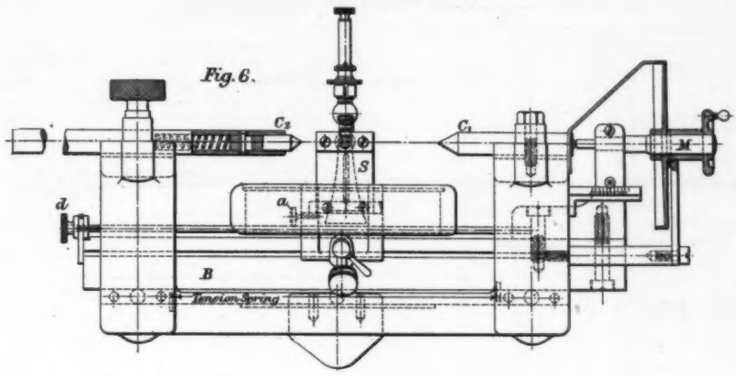
We turn to the description of the screw-gauge measuring machines to which we alluded above. One of the chief points of these novel machines is that they are simple and easy to work without straining the eye of the observer. We might perhaps single out the names of Messrs. E. M. Eden, M.Sc., B. P. Dudding, A.R.C.Sc., and F. H. Rolt, B.Sc., among those of Mr. Sears' assistants chiefly responsible with him for the design and development of these machines. The simplest type of floating and tipping machine in use serves for measuring effective and core diameters with the aid of small needles (round) or prismatic V-bars of steel, which are suspended by threads from swinging arms and fitted into opposite grooves of the screw, which is supported between centres. The micrometer face and anvil bear against the needles at right angles to the screw when a reading is taken; the micrometer is carried on a saddle with V-grooves and rests on balls which keep it square and yet leave it free to measure. In the tipping machine the micrometer tips about a hemispherical bearing in a V-groove, again being kept square to the screw, which is mounted on centres.

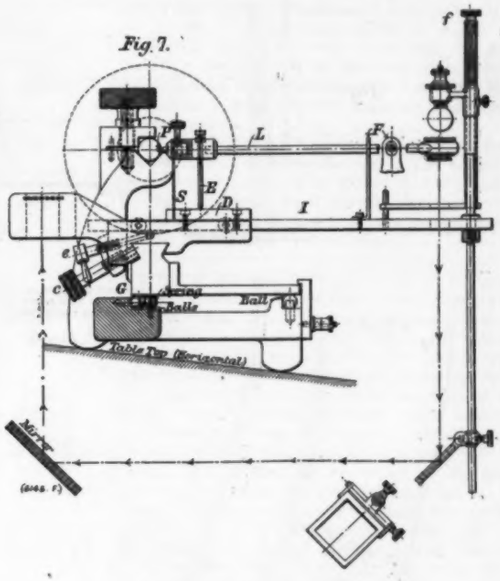
The plate and screw gauge projecting machines are used in various forms. In the simplest horizontal form the lamp beam throws the magnified image of the thread on the wall opposite, on which irregularities at once become visible and measurements can be taken. Ring gauges are also examined in this way. A fairly liquid paste of plaster and some oil is smeared into a portion of the ring so that a casting in the shape of a cylindrical segment, flat on top, is produced; the gauge is previously cleaned with petrol and the casting brushed with it. The vertical projector for screw gauges illustrated in the diagram Figs. 2 and 3 is a more elaborate machine. The idea is that a horizontal beam of parallel rays from a pointolite (tungsten bead) lamp and a collimator is reflected upward past the screw, projecting an image of the screw thread through a lens and a hole in the hinged table (in front of which the observer stands) on to a horizontal plane mirror (fixed to the wall), which reflects the image down again on the table. The observer places a board of the thread-form diagram on the table and shifts it until the shadow image and thread form coincide; comparison and measurements then follow. The magnification used is 50 diameters. The screw gauge A is held between centres on a carrier B, which slides in the direction of the screw axis and can be pushed by hand to bring any particular thread under the projecting lens, and can also be rotated by hand; by means of a micrometer screw, not shown, the carrier can further be moved horizontally at right angles to the screw axis, and the front or back of any size screw thus be brought under the lens. This lens D is fixed to the underside of the table C and focused on the centres; E is the plane mirror above. The thread form is drawn dotted on the board F and is held by hand against the adjustable edge G; the shadow-like image of the thread examined appears superposed on the diagram, and may be further adjusted to the diagram by the micrometer screw. With the aid of the shadow protractor (Figs. 4 and 5), which is pushed up to the thread shadow, the angle of thread and out-of-squareness may be easily determined, and the machine further serves for discovering variations from the thread form such as thick threads, bad angle and bad radius, &c. Such irregularities, best found out in this way, are traced on a label, which is returned to the gauge maker. When the image is superposed on the diagram, and the micrometer turned to bring the other side of the screw over the diagram, the distance traversed is the effective diameter. The full and core diameters can be similarly measured, and by adding another micrometer screw, or using, say, ½-in. distance-pieces, the pitch can be determined. This latter micrometer is not usually fitted to the machine, however, as such measurements are preferably made on the next machine to be described, except in the case of small B.A. gauge screws, for which the mechanical needle devices already mentioned would not be suitable.

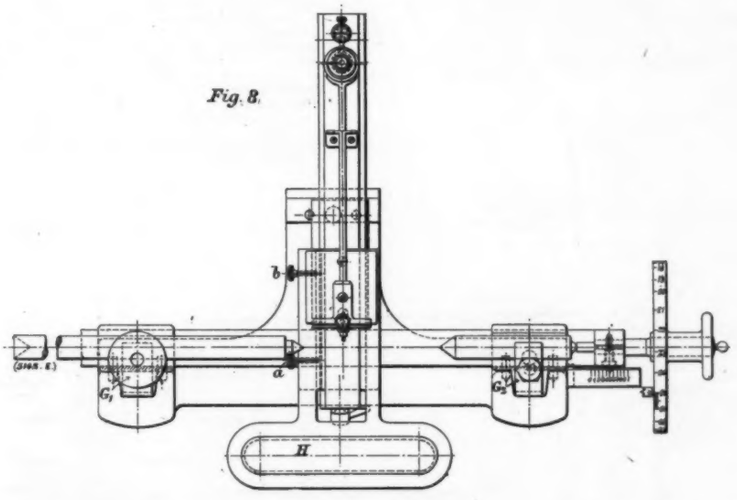


The light is "raked" in the direction of the screw threads by sliding the prism H on the curved sector J by the aid of a lever (not shown); correct

raking is judged by the symmetry or out of focus of the image shown when a long-focus negative spectacle lens is momentarily placed over the projection lens. To look at the other side of the screw the light has to be raked in the opposite direction; the position which the prism then occupies is shown dotted. The table C on which the image is projected is 16 in. square, almost the whole of that area being available for the image. When a new screw is to be put in or the mechanism to be examined the table is turned up on its hinges. The field of view of this machine is only about $\frac{1}{2}$ in., whilst the large horizontal machines have a field of view of 2 in. The machine is also useful, however, for measuring small profiles and radii and threading tools in particular, and a small machine of similar type, with ordinary table, is now being made for screw-gauge makers.







The pitch-measuring machine illustrated in Figs. 6, 7 and 8 is of quite a different type. The screw to be tested is held between centres C_1 and C_2, the latter being adjustable in its V groove to take gauges of different lengths. The bar B is guided on three steel balls and by the two side guides G_1 and G_2 to move in the direction of the screw axis. The sliding bar B carries the micrometer head M, the end of which presses against the hardened spherical end of the fixed centre C_1. The indicator device I—comprising the lever with its point P at one end and a lens at the other, the block D, the steel strip S and the strut E—is also attached to the bar B; it is clamped by means of the thumb screws *a*, *b*, *c*, and further adjusted by means of the knurled nut *d* and the clamp screw *e*. The whole machine rests on an inclined bed, as will be seen from Fig. 7 (in which the horizontal table is drawn inclined); the object is to have little friction combined with accurate lateral guiding, the vertical guiding not having so much effect on the pitch measurement, because the micrometer is at the same height as the indicator point P for all screw diameters. The large dial of the micrometer head M is divided into 250 divisions of 0.0001 in.; there is a further scale on the barrel, where it is more easily seen than under the thimble.

The peculiar feature of the machine is the steel strip S, which, capable of both bending and twisting, acts as a pivot for the lever L and allows it a certain lateral play, limited by the sides of the slot F through which the lever passes. We will call the sides of the slot the left and right stop. The ratio of the short lever arm from S to the point P to the long arm from S to the lens is 1 : 18, the actual length of the lever being 7 in. Above the lens, a microscope objective of 1 in. focal length, is a small 2-volt lamp (Fig. 7); the light from this lamp passes down and is reflected by the mirrors (Fig. 7) on the lower surface of the ground-glass screen H (Fig. 8), which bears a zero mark in its centre. In use the micrometer dial is first set to 00 or to 01, and the indicator is adjusted so that the ball-ended point P touches both sides of the screw thread with a slight pressure; the nut *d* must be so adjusted that the lever lies in the middle of the slot F; and the exact position of the lever is determined by watching the filament image of the lamp on H, the focusing being effected by means of the screw *f* (Fig. 7). In this symmetrical position the strip S is straight and not twisted. When the micrometer screw is now turned, the strip S yields by bending and twisting; at the same time the strut E slightly inclines back, away from P; the lever point P bears against the right-hand flank of the thread, and the other end of the lever is stopped by striking the right stop. When the micrometer movement is continued, point P climbs up the thread, moves over the crest, and bears against the left flank of the next thread, while the far end of the lever tilts over until arrested by the left stop. Finally P drops into the bottom of that thread, and the light spot, which has been jerkily shifted during this movement, returns to zero; at that moment, which cannot be mistaken, a new reading is taken. The difference between the micrometer dial readings and the calculated values for a screw of perfect pitch gives the errors. The ball-ended point P is removable and is adapted to the thread under test; the block D can be adjusted to and from the centres to take gauges of different diameters. The lens used magnifies 26 times, which, combined with the lever ratio of 18 : 1, gives a total indicator magnification of 468.

(To be continued.)

JAPANESE OUTPUT AND EXPORT OF COPPER ORE.—H.M. Commercial Attaché at Yokohama, says *The Board of Trade Journal*, has forwarded the following information relative to the copper ore output and trade of Japan in 1916, which has been furnished to him by the largest copper mine-owners in that country, who also do a large export business in copper:—According to the company's statement, the output of copper ore in Japan in 1916 amounted to 111,562 tons, as compared with 83,017 tons in 1915 and 78,700 tons in 1914, while exports amounted to 57,402 tons in 1916, as against 56,528 tons in 1915 and 43,305 tons in 1914. Russia now buys most of Japan's copper ore, her purchases amounting to 60 per cent. of the total exports. The United Kingdom takes 20 per cent., while France, the United States and India share the balance, but their dealings are not large. The consumption of copper ore in Japan has increased considerably during the last three years, the consumption in 1916 amounting to 59,690 tons, as compared with 27,723 tons in 1915 and 32,045 tons in 1914.

STRENGTHENING OF POUGHKEEPSIE BRIDGE.—The first point, from its entrance into New York Bay, at which the River Hudson is bridged is 73 miles from the Grand Central Station, New York City, or more than half-way to Albany. This is by the cantilever bridge at Poughkeepsie, by which the Central of New England Railway joins the New York, New Haven and Hartford Railroad with the systems in New Jersey and other States west of the Hudson River. The length of the bridge proper is 3,094 ft., of which there is a centre cantilever span of 546 ft., flanked by two anchor spans of 525 ft. each and two cantilever spans, each of 548 ft., which have anchor arms forming 200-ft. shore spans. The height is about 165 ft. above water-level, and a double line of rails is carried. The bridge was opened in 1888 and was strengthened in 1906. With the great increase in engine and train loading of the past few years, says *The Railway Gazette*, the bridge could not safely carry these loads on both tracks simultaneously, nor could it be reinforced to such an extent as to do this. The alternatives were to eliminate the possibility of both lines being used at the same time or to build a new bridge. The former plan was adopted, as the cost will be relatively small; and although the traffic is heavy, it can be handled without trouble over the single-track links. The principal change in the bridge will be the reconstruction of the floor system, using long and heavy floor-beams that will distribute the load over the three lines of trusses. With the present double-track arrangement each track has an independent floor system. The spans and towers of the approach viaducts will be reinforced, and the new single track will extend over part of the length of these approaches. The rails of the two tracks will be paralleled over this single-track section, so as to avoid the necessity of switch connections at the ends.

GASHOLDER AT THE TOTTENHAM LIGHT, HEAT AND POWER CO.'S WORKS.

MR. A. E. BROADBERRY, M. INST. C.E., CHIEF ENGINEER.

(*For Description, see opposite Page.*)

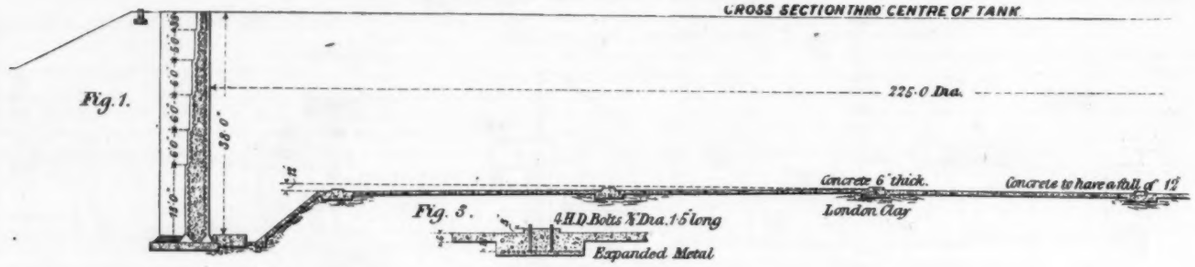


Fig. 1.

Fig. 3.

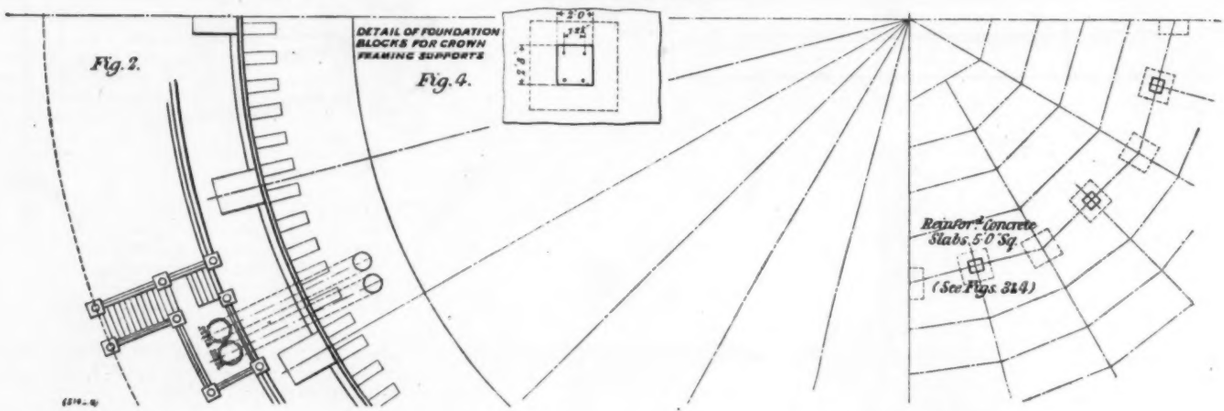


Fig. 2.

Fig. 4.

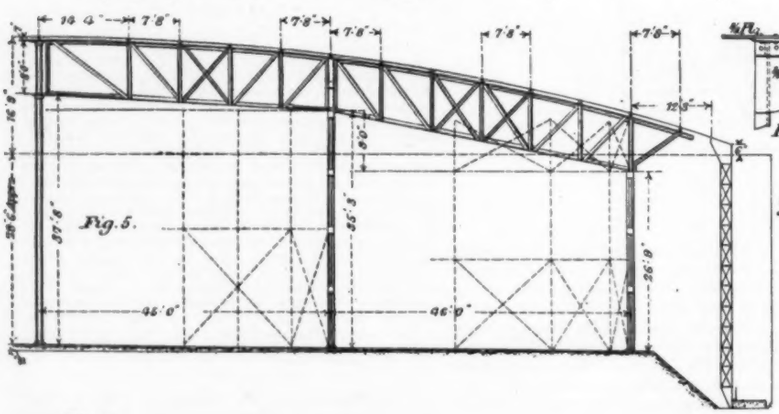


Fig. 5.

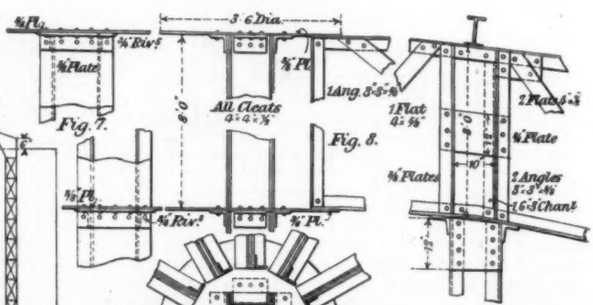


Fig. 7.

Fig. 8.

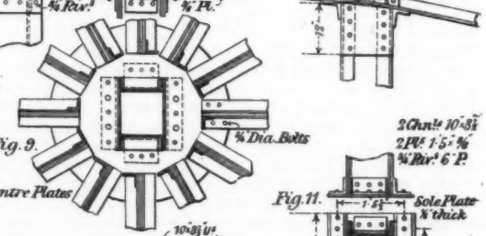


Fig. 9.

Fig. 11.

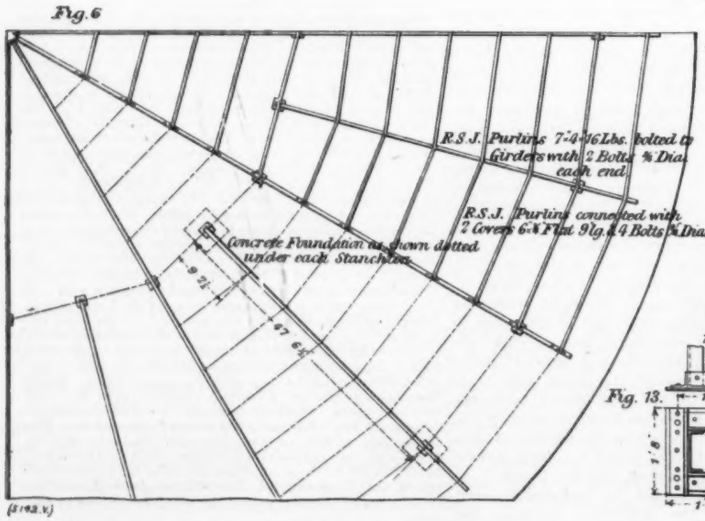

R.S.J. Purlins 7·4·16 Lbs. bolted to Girders with 2 Bolts ¾ Dia. each end.
R.S.J. Purlins connected with 2 Covers 6·¾ Flat 9 lg. & 4 Bolts ¾ Dia.
Concrete Foundation as shown dotted under each Stanchion.
97 6½

Fig. 6

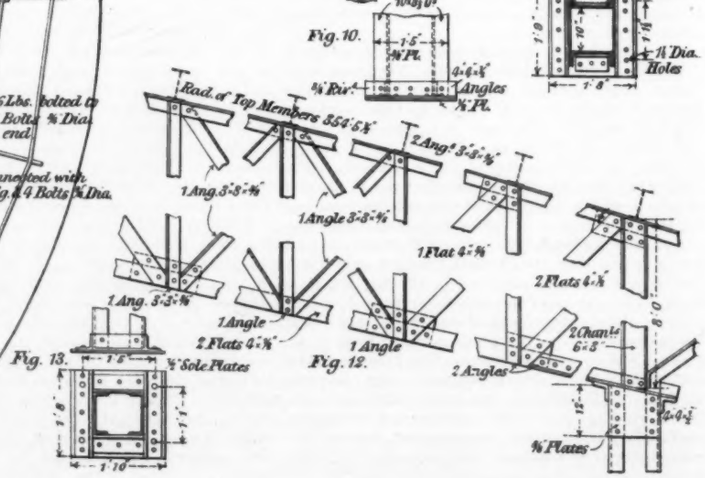


Fig. 10.

Fig. 12.

Fig. 13.

GASHOLDER AT THE TOTTENHAM LIGHT, HEAT AND POWER COMPANY'S WORKS.

MR. A. E. BROADBERRY, M. INST. C.E., CHIEF ENGINEER.

Fig. 14.

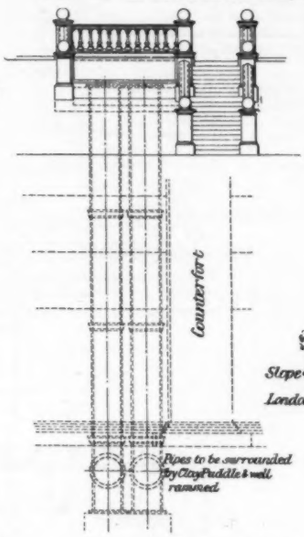


Fig. 15.

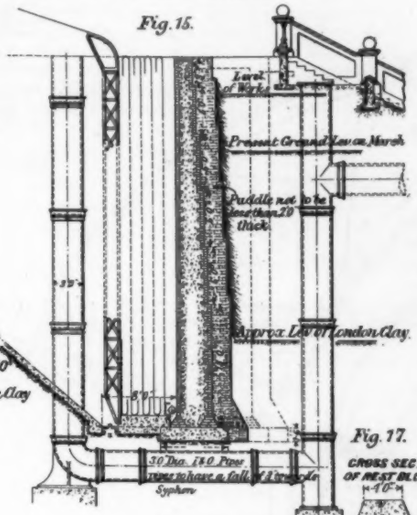

Present Ground Level or Marsh
Puddle not to be less than 20' thick
Approx Level of London Clay
Slope 40°
London Clay
30 Dia. 14 0 Pipes
Syphons

Fig. 17.

Fig. 18.

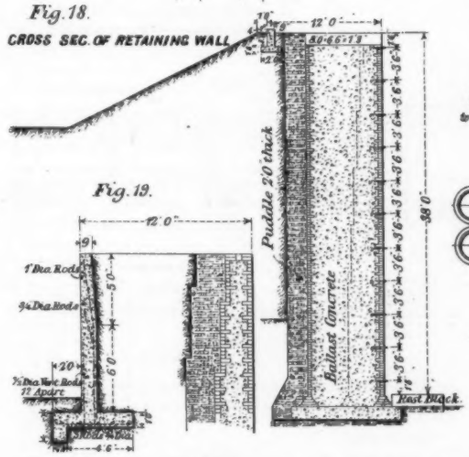


Fig. 16.

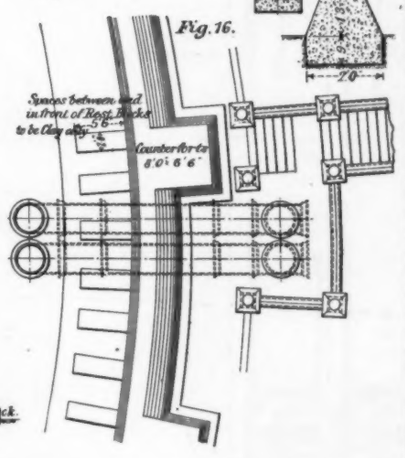


Fig. 19.

WE illustrate on Plate I and on the present page and pages 6 and 8, the five-lift 6,750,000 cub. ft. gasholder which the Tottenham Light, Heat and Power Company, whose works we described in our issue of June 22, is to erect to complete the new extension of its plant. The holder was designed by the company's chief engineer, Mr. A. E. Broadberry, M.Inst.C.E.

The brick tank, of which views are given in Figs. 1 and 2 on page 6, has already been constructed by Messrs. Cyrus Robinson and Co., of Queen Anne's-chambers, Westminster. It was commenced in September, 1913, and was completed the following year. It has a diameter of 225 ft., and a depth of 39 ft. 3 in. from coping to the floor. The wall and the piers for the gasholder standards are of 6 to 1 Portland cement concrete, and are faced with brickwork. Bands of Exmet, made by the Expanded Metal Company, were inserted as reinforcement at intervals of 2 ft. in the depth of the walls and of the piers. The brick facing is of 4½-in. work, every fourth course in height being a header for the purpose of bonding with the concrete. The wall is carried up 10 ft. above the surrounding ground level, and the coping is of blue Staffordshire bull-nosed bricks. Mr. Broadberry's reason for keeping the coping at this high level was to ensure, as far as possible, that the trench excavation, at its maximum depth of 40 ft., should not pierce similar faults in the clay to those experienced on other excavation work which had been carried out in the neighbourhood.

The annular trench for the wall, piers, and 36-in. inlet and outlet pipes, varying from 10 ft. to 25 ft. in width, passed through about 7 ft. of light soil and peat, 15 ft. of clean gravel or ballast, and 14 ft. of clay. The trench was timbered with 3-in. runners, 4-in. and 6-in. walings, and 10-in. to 12-in. struts. For the lower frames, in the clay, poling boards were substituted for the runners. The wall was backed with 24 in. of puddle from clay excavated from the trench and passed through a pug mill. Two large sumps with cross trenches were sunk slightly in advance of the main trench. The flow of water from the gravel to these sumps, and to the main trench, was so considerable as to necessitate the keeping fully running day and night of a 9-in. and a 6-in. centrifugal pump, a 14-in. rocker pump, and several pulsometers. Much difficulty was experienced, through pockets and the uneven surface levels of the clay, in preventing rushes of water on to the puddle and wall during the progress of the work.

The material from the trench excavation was filled into handcarts, which were hoisted away by steam cranes in the usual manner. This system of working by handcarts is believed to be novel. The handcarts, after filling, were run on rails right up to the side of the wall, were hoisted away, and tipped direct where required for the formation of the embankment surrounding the wall. By this means the necessity for filling, emptying, refilling and tipping is avoided, and the work carried out more expeditiously than would be the case by the usual methods of working. The surplus material, with the exception of the ballast, of which there was a very large quantity, was run to spoil and, as before stated, used in forming the embankment.

The bricks used, 500,000 in number, were manufactured locally. The concrete (4,700 cub. yards were needed) was made of ballast from the site, The capacity of the trench excavation was 10,500 cub. yards, and of the general excavation 31,000 cub. yards. Of timbering, 53,000 ft. super. were employed, and there were 3,500 cub. yards of puddle. The capacity of the tank, not including the dumpling, is 1,560,614 cub. ft.; multiplying by 6.25 gives 9,753,837 as the capacity in gallons of water required.

For testing, the holder will be filled with air until the air blows out under the curb. The holder will then be lowered 3 ft., the blower shut off, and the holder must prove itself airtight during a period of three days, allowance of course being made in testing for atmospheric variations.

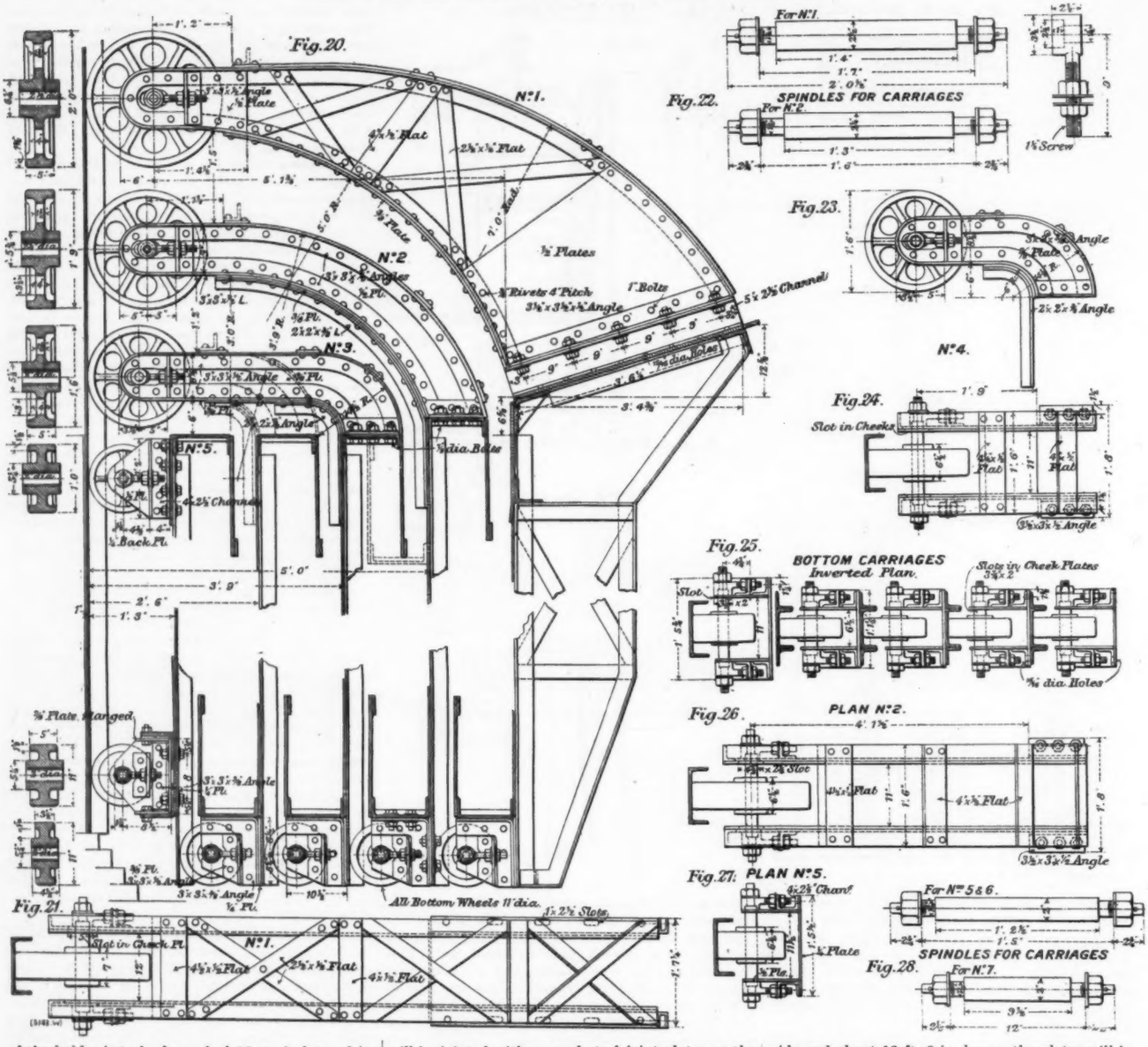
The construction of the holder is to include the erection of the framing in the tank for supporting the crown, and also of the tank guides (Figs. 5 to 13, page 6). The crown framing will consist of rows of purlins of rolled steel joists (Figs 5 and 6) carried on 12 girders radiating from the centre, and 24 girders forming an outer ring also radiating from the centre. The girders will be supported by two rings of stanchions braced together, and one centre stanchion. There will be 12 rows or rings of purlins of 7 in. by 4 in. by 16 lb. rolled steel joists spaced 7 ft. 6 in. apart. The purlins will be bolted to the girders by two ¾-in. bolts at each end, and will be connected together by a pair of fishplates 6 in. by ¼ in. by 9 in., bent to the proper angle at each joint; four ¾-in. bolts will be used for each bar of fishplates. The 12 girders radiating from the centre will be 8 ft. deep by about 45 ft. long. The top member will be formed of two angles 3 in. by 3 in. by ⅜ in.; the bottom member will be one flat bar 4 in. by ⅜ in., with extension at each end of the two angles 3 in. by 3 in. by ⅜ in. The struts will be formed of 3 in. by 3 in. by ⅜ in. angles respectively, single, double, single, single, double, double as taken from the centre. The diagonal ties, taken from each end, will be, first, 4 in. by ⅜ in. flat, and second, 4 in. by ⅜ in. flat. At the centre there will be two angles 3 in. by 3 in. by ⅜ in. There will be 12 girders about 46 ft. long (Fig. 5) forming a continuation of the others, and 12 similar girders fixed centrally between them. Circumferential bracing will be provided as shown in Fig. 6. Between the girders (at each end of the outer series) there will be diagonal bracing of 2 in. by ⅜ in. flat. Between the stanchions a ring of 2½ in. by ⅜ in. flat at the centre of their height, and between this ring and the feet diagonal bracing of 2½ in. by ⅜ in. flat. All the bracing will be attached to the girders and stanchions by ¾-in. bolts.

The 48 tank girders will each be 10 in. by 3½ in. by ½ in. channel, fixed perfectly plumb at equal distances round the tank; 24 of them will be exactly in line with the channel guides on the face of the standards, and attached to them by 3½ in. by 3½ in. by ½ in. angles not less than 3 ft. long and having eight ⅞-in. bolts to each angle. The channel guides will be provided with 11 pairs of wing plates 3½ in. by 3½ in. by ½ in. by 9 in. long riveted on by ¾-in. rivets countersunk on the inside.

In regard to the gasholder itself, the contract for this was let in 1914 to the Berlin Anhaltasche Maschienbau Actien Gesellschaft, known as the B.A.M.A.G., but owing to the outbreak of war it, of course, lapsed. The Tottenham company thereupon made arrangements for executing the construction themselves; but again, in consequence of labour difficulties occasioned by the war, were unable to proceed with the work. The construction of the holder therefore has had to be postponed, but will be proceeded with as soon as circumstances permit. It is of the greatest importance that it should be available for use at the earliest possible moment, as the output of gas is increasing so rapidly. The new vertical retort section of the works alone is capable of producing 4,750,000 cub. ft. per day. The inner lift of the holder will be 212 ft. 4 in. diameter, measured to the face of the vertical stay plates, and 38 ft. 6¾ in. deep from the bottom of the cup to the top side of the curb plate. The top curb

GASHOLDER AT THE TOTTENHAM LIGHT, HEAT AND POWER CO.'S WORKS.

MR. A. E. BROADBERRY, M. INST. C.E., CHIEF ENGINEER.



of the holder is to be formed of 96 steel plates, $\frac{3}{8}$ in. thick, cut to correct shape.

The joints will be planed so that they accurately butt each other, and will be joined with an inner and outer butt strip, 9 in. wide by $\frac{7}{16}$ in. thick, double riveted with $\frac{7}{8}$-in. rivets at 4 in. pitch. The outer edge of each plate will be stiffened with two 3-in. by 3-in. by $\frac{1}{2}$-in. angles with $\frac{7}{8}$-in. rivets. The inner corners of the web plates will be connected by one 3-in. by 3-in. by $\frac{1}{2}$-in. steel angle, bent to the correct radius. This angle will be connected horizontally to the bottom curb and vertically to the top curb by 3-in. by $\frac{1}{2}$-in. struts and 3-in. by $\frac{1}{2}$-in. lattice bars, as shown. There will be 48 vertical stays inside the holder, one opposite each standard and intermediate guide. Each of these stays will consist of double steel angles, 3 in. by 3 in. by $\frac{3}{8}$ in., with $2\frac{1}{2}$-in. by $\frac{3}{8}$-in. lattice bars, and will be 1 ft. 9 in. in depth. At the top each stay is to be connected to the crab-plate angles by $\frac{7}{8}$-in. rivets. The feet of the stays will project 12 in. below the cup, in order to receive the bottom guide carriages.

The bottom cup, Fig. 20, will be formed of 10-in. by $3\frac{1}{2}$-in. channels bent to the proper sweep, and will be jointed with pressed steel joint plates on the inside of the cover plates and riveted with $\frac{7}{8}$-in. rivets at 3-in. pitch. The inside of the cup is to be 2 ft. 4 in. deep; the outer edges will be strengthened by a steel flat, 3 in. by $\frac{1}{2}$ in., riveted on with $\frac{7}{8}$-in. countersunk rivets at 4-in. pitch. Wrought-iron bearing pieces, 8 in. by 2 in. by 1 in. thick, will be secured to each cup channel by two $\frac{7}{8}$-in. countersunk rivets, so as to give a level bearing to the grip.

In regard to the side sheets, the vertical stays will be riveted to a vertical plate, $\frac{1}{4}$ in. thick by 1 ft. 1 in. wide by 37 ft. 6 in. long, in one piece, with $\frac{7}{8}$-in. rivets at 8-in. pitch. This vertical plate will be riveted to the main curb plate and to the cup plates. The row of plates next the curb plates will be $\frac{1}{4}$ in. thick by 3 ft. $2\frac{1}{2}$ in. deep, and the row above the cup $\frac{1}{4}$ in. thick by 3 ft. 2 in. deep. The top row will be riveted to the $\frac{3}{8}$-in. plates by $\frac{7}{8}$-in. rivets, $2\frac{3}{8}$-in. pitch, and the bottom row will be riveted to the cup plate by $\frac{3}{8}$-in. rivets at 2-in. pitch. The remainder of the sheeting will be of No. 10 S.W.G. by 3 ft. $2\frac{3}{8}$ in. deep or 3 ft. $1\frac{1}{2}$ in. centres.

The crown sheets of the holder, next the $\frac{5}{8}$-in. plates will be $\frac{5}{16}$ in. thick and 48 in number, 3 ft. wide and about 13 ft. 8 in. long; the plates will be lap-jointed, thinned out, and tucked under the butt strips of the $\frac{5}{8}$-in. plates where these occur. The remainder of the crown sheeting will be either radial or herring-bone, but in either case the plates next the $\frac{7}{16}$-in. plates will be No. 7 S.W.G. and the remainder No. 10 S.W.G.

The riveting will be as follows:—

Sheets of No. 10 S.W.G.—$1\frac{1}{8}$-in. lap, $\frac{7}{16}$-in. diameter, $1\frac{1}{8}$ in. pitch.
Sheets of No. 7 S.W.G.—$1\frac{1}{4}$-in. lap, $\frac{7}{8}$-in. diameter, $1\frac{1}{4}$-in. pitch.
Sheets of $\frac{1}{4}$ in. thickness—$1\frac{1}{4}$-in. lap $\frac{7}{8}$-in. diameter, $1\frac{1}{4}$-in. pitch.
Sheets of $\frac{7}{16}$ in. (cups and grips)—$2\frac{1}{8}$-in. lap, $\frac{7}{8}$-in. diameter, 2-in. pitch.
Sheets of $\frac{5}{8}$ in. (cups and grips)—$2\frac{1}{4}$-in. lap, $\frac{7}{8}$-in. diameter, $2\frac{1}{4}$-in. pitch.

A seal plate to surround the in and out pipes is to be attached to the crown sheeting. The upper portion of this plate is to be $\frac{3}{8}$ in. thick, the lower part $\frac{7}{16}$ in. thick, and is to extend 15 in. below the coping level of the tank. It is to be attached to the crown sheeting by 3-in. by 3-in. by $\frac{3}{8}$-in. angle ring with moulded joint. In the centre of one side an

8-in. diameter hole will be cut, and an 8-in. rack-and-pinion valve bolted thereto.

Counterbalance weights to compensate for the weight of the sealing arrangement are to be attached to the underside of the roof sheets in two places, so that the three weighted points will form an equilateral triangle. There will be a manhole, 3 ft. 6 in. diameter, over the inlet pipe and over the outlet pipe. The opening of each will be stiffened by a welded ring, 3 in. by $\frac{1}{2}$ in. in section, riveted on by $\frac{3}{4}$-in. rivets of 4-in. pitch.

The dimensions of the other four lifts of the holder will be as follow (see Fig. 20, page 8):—

Second lift, 214 ft. 10 in. diameter from faces of the vertical stay plates.
Third lift, 217 ft. 4 in. diameter from faces of the vertical stay plates.
Fourth lift, 219 ft. 10 in. diameter from faces of the vertical stay plates.

Each lift will be 38 ft. deep measured from the bottom of the cup to the top of the grip outside plates. All the cups of the second, third and fourth lifts will be the same as those described for the first or inner lift.

There will be 48 vertical stays to each lift, constructed of $7\frac{3}{32}$-in. by $2\frac{1}{2}$-in. by 18.21-lb. steel channel (in one piece) riveted to a steel angle 3 in. by 3 in. by $\frac{1}{4}$ in. on each side, with $\frac{5}{8}$-in. rivets countersunk in the channel, 8-in. pitch. The angle will be riveted to a vertical plate, $\frac{1}{4}$ in. thick by 13 in. wide by 38 ft. 6 in. long, in one piece; $\frac{5}{8}$-in. diameter rivets will be used, pitched at 8 in. Any joints in these angles will be fitted with $\frac{3}{16}$-in. angle cover plates, 18 in. long, and countersunk rivets of $\frac{5}{8}$-in. diameter. The row of plates next the cup and grip will each be $\frac{1}{4}$ in. thick by 2 ft. $11\frac{5}{8}$ in. deep; the rivet centres being 2 ft. $8\frac{1}{4}$ in. They will be riveted to the $\frac{7}{16}$-in. cup and grip plates by $\frac{5}{8}$-in. rivets placed at 2 in. pitch. The remainder of the side sheeting will be of No. 10 S.W.G., 3 ft. $2\frac{5}{8}$ in. deep, riveted at 3-ft. $1\frac{1}{2}$-in. centres.

The outer lift, No. 5, of 222 ft. 4 in. diameter to the face of the vertical stay plates, will be 38 ft. deep measured from the bottom of the curb to the top of the grip plate. The grip of this lift will be the same as for lifts 2, 3 and 4 (Fig. 29).

The bottom curb will be 15 in. deep and will consist of two steel angles, 6 ft. 6 in. by $\frac{5}{8}$ in., riveted to the $\frac{1}{4}$-in. plates forming the bottom row of the side sheeting with $\frac{3}{4}$-in. rivets, 6-in. pitch, zig-zag. The angles will be in long lengths joined with carefully fitted angle covers, $\frac{1}{4}$ in. thick, not less than 3 ft. long, riveted with $\frac{3}{4}$-in. rivets.

The row of plates next the grip will be $\frac{1}{4}$ in. thick, 2 ft. $11\frac{5}{8}$ in. deep, the centre lines of rivets being 2 ft. $8\frac{3}{4}$ in. apart. The bottom row will consist of $\frac{1}{4}$-in. plate, 3 ft. in depth. The row next above will be of No. 7 S.W.G., 2 ft. 3 in. deep; and the remainder will be No. 10 S.W.G., 3 ft. $2\frac{5}{8}$ in. deep, with riveting spaced at 3 ft. $1\frac{1}{2}$ in. centres. The vertical stays of this outer lift will correspond with those of lifts 2, 3 and 4.

There will be 24 top carriages to the inner lift, formed of 3-in. by 3-in. by $\frac{1}{4}$-in. angles, $\frac{1}{2}$-in. web plates with $\frac{3}{8}$-in. cover plate at the top and underside of each, as shown in Figs. 20 and 21, on page 8. All the riveting will be $\frac{3}{4}$ in. Each of the carriages will be secured to bases of Z-iron by means of eight bolts, $\frac{7}{8}$ in. diameter. The channel bases will be 5 in. by 3 in. by $2\frac{1}{2}$ in., riveted to the curb plates by seven rivets, each of $\frac{7}{8}$ in. diameter, and made perfectly gastight.

On the second lift there will be 24 carriages formed of 3-in. by 3-in. by $\frac{1}{4}$-in. angles with $\frac{1}{4}$-in web plates, with $\frac{3}{8}$-in. cover plates at the top and underside. The carriages will be riveted to the grip channels and side sheeting, the carriage angles being extended to enable this to be done (see Fig. 20).

The third lift will have 12 carriages, similar (except in length) to those for the second lift, but the web-plate will be $\frac{3}{8}$ in. in thickness. There will be 12 carriages on the fourth lift, similar (except in length) to those on the second and third lifts, but arranged alternately with those on the third lift. The fifth lift will be provided with 24 carriages formed of two channels, 4 in. by 3 in., riveted to a back plate, $\frac{1}{4}$ in. thick, and having web-plates $\frac{1}{2}$ in. thick. The carriages will be bolted to the grip by eight $\frac{3}{4}$-in. bolts each.

Cast-iron rollers will be fitted to the carriages as follows (see Figs. 20 to 27, page 8):—

Inner lift: rollers 24 in. diameter, 5-in. face.
Second lift: rollers 21 in. diameter, 5-in. face.
Third lift: rollers 18 in. diameter, 5-in. face.
Fourth lift: rollers 18 in. diameter, 5-in. face.
Fifth lift: rollers 12 in. diameter, 5-in. face.

The rollers will turn on gun-metal bushes, $2\frac{1}{2}$ in. outside diameter, fitting between the cheek plates of the carriages, with a mild steel $1\frac{1}{2}$-in. pin passing through them. The pins will have a nut and pin at each end and wrought-iron washers will be fitted between the rollers and the cheek plates as required. The mild steel pins will pass through 1-in. eyebolts for adjustment purposes, these eyebolts being secured to angle-iron pieces on the brackets, with nut on each side. The bottom carriages of all, except the outer lift, will be formed of 3-in. by 3-in. by $\frac{3}{8}$-in. angles with $\frac{3}{8}$-in. web-plates. The angles will be riveted to a back plate $\frac{1}{4}$ in. thick, and the carriage will be secured to the continuation of the vertical stay by four $\frac{3}{4}$-in. bolts.

There will be 48 carriages to each lift. The bottom curb of the outer lift will be fitted with 48 carriages between the angles forming the curb. They will be formed of two 3-in. by 3-in. by $\frac{3}{8}$-in. angles, $\frac{3}{8}$-in. web-plates, and $\frac{1}{4}$-in. back plate. They will be bolted to the curb angles by four bolts on each side.

The 48 rollers for the bottom of the outer lift will be 11 in. in diameter and 5-in. face. All the others will be of that diameter, but $3\frac{1}{2}$-in. face. All the rollers will be of cast-iron and will turn on steel bushes, $2\frac{1}{2}$ in. diameter, secured between the cheek plates of the carriages by $1\frac{1}{2}$-in. mild steel pins. These pins will have a nut and split pin at each end and will pass through 1-in. eyebolts for the purpose of adjustment. The eyebolts will pass through angle-iron brackets riveted to the carriages, with a nut at each side.

The carriages of the first, second and third lifts will be stiffened by angle-raking stays. Those to the first lift will be of 3-in. by 3-in. by $\frac{5}{8}$-in. angle secured to the carriage by two $\frac{3}{4}$-in. rivets, and to the curb plate by two $\frac{3}{4}$-in. rivets at each end. Those of the second lift will be of 3-in. by 3-in. by $\frac{1}{2}$-in. angle secured to the carriage by two $\frac{3}{4}$-in. rivets and to the grip plates by two $\frac{3}{4}$-in. rivets at each end. Those to the third lift will be of 3-in. by 3-in. by $\frac{3}{8}$-in. angles secured to the carriage and grip plates as in the second lift.

Turning to the guide-framing, there will be 24 cast-iron base plates for the standards. These base plates will each be 7 ft. 10 in. long and 9 in. deep, ribbed externally and internally. The thickness of the metal in all parts will be $1\frac{1}{2}$ in. Each base will have seven holes, $1\frac{3}{4}$ in. diameter, cast in for the holding-down bolts, and seven holes, 1 in. diameter, for bolting to the standards.

There will be 24 standards, each built up in five lengths, as shown in Figs. 29 to 38 on Plate I, the top piece being 37 ft. 9 in. long, and each of the others 37 ft. 4 in. long. They will be tapered so as to give a uniform batter to the outside when the five pieces are bolted together. The first or bottom piece, Fig. 34, will be 7 ft. $6\frac{1}{4}$ in. wide at the bottom and 6 ft. wide at the top at centre of the gusset plates, and will consist of two steel channels, 10 ft. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., at the tank face, riveted together by a 10-in. by $\frac{1}{2}$-in. steel plate between them; the rivets, of 1 in. diameter, countersunk on the face, will be pitched at 12 in., zig-zag.

The back member will be two steel angles, 8 in. by 8 in. by $\frac{3}{4}$ in. The channels and angles will be riveted at the base to a welded angle frame, 6 in. by 6 in. by $\frac{3}{4}$ in., with holes drilled in it for the holding-down bolts. To the centre of the bottom frame of 6-in. by 6-in. by $\frac{3}{4}$-in. angles on each side of the standard, will be riveted a piece of steel plate, 6 in. by $\frac{3}{4}$ in. by 21 ft. long, with hole $1\frac{13}{16}$ in. diameter through it and the gusset plate and the angle frame, for the pin to secure the bottom end of the diagonal ties.

The bracing of the guide-framing will consist of two struts on each side and back of 4-in. by 4-in. by $\frac{1}{2}$-in. T, to which will be riveted stiffening plates, $\frac{1}{4}$ in. thick, three struts of $4\frac{1}{2}$-in. by $\frac{3}{4}$-in. flat, and six pairs of lattice bracings of $4\frac{1}{2}$ in. by $\frac{3}{4}$ in. on each side and back of the standard. At the top and bottom there will be shaped gusset plates, $\frac{3}{4}$ in. thick, six in all, and to each of the top gussets will be riveted two steel angles, $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. by $\frac{1}{2}$ in., with a stiffening plate $\frac{3}{4}$ in. thick between them.

The riveting of the guide-framing will be as follows:—

Bottom, 6-in. by 6-in. angle to gussets: $\frac{3}{4}$ in. rivets, two rows, 6-in. pitch.
Channels and angles to gussets: 1 in. rivets, two rows, 6-in. pitch.
Tee struts and lattice bars: two rivets, 1 in. diameter at each end of each member.
Stiffening plate to tees: $\frac{5}{8}$-in. rivets at 6-in. pitch.
Angles to top gusset plates: 1 in. diameter, 6-in. pitch, countersunk; also 1-in. bolts between for bolting to girders. The same angles to $\frac{3}{4}$-in. top stiffening plate, $\frac{3}{4}$-in. rivets, 6-in. pitch.

The second length of each standard (Fig. 35) will be constructed like the first length, but no bottom angle frame will be required. It will be 6 ft. wide at the bottom and 5 ft. wide at the centre of the top gussets. At the tank face there will be two steel channels, 10 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., with 10-in. by $\frac{3}{4}$-in. plate between. At the back there will be two steel angles, 7 in. by 7 in. by $\frac{3}{4}$ in., and 4-in. by 4-in. by $\frac{1}{2}$-in. tee struts. There will be stiffening plates, $\frac{1}{4}$ in. thick, and lattice struts and bars, 4 in. by $\frac{3}{4}$ in. flat. The top angles to gusset plates will be secured by material 4 in. by 4 in. by $\frac{1}{2}$ in., and the stiffening plates will be $\frac{3}{4}$ in. thick and the gussets $\frac{3}{4}$ in. thick. The riveting will be as for the first length.

The third length of the standard will be of similar construction to the second, but 5 ft. wide at bottom and 4 ft. wide at the top of the gusset centres. At the tank face the two steel channels will be 10 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in. At the back the angles will be 6 in. by 6 in. by $\frac{3}{4}$ in. The tee struts will be 4 in. by 4 in. by $\frac{1}{2}$ in.; the lattice struts and bars, 4 in. long, $\frac{5}{8}$ in. flat; and the top gusset plates $\frac{3}{4}$ in. thick. The rivets will be as before, except that $\frac{7}{8}$-in. rivets will be used on connections to the main channels and angles instead of 1-in. and $\frac{7}{8}$-in. bolts and rivets to the angles at the top gussets.

The fourth length of the guide-framing will follow the design of the second and third, but will be 4 ft. wide at the bottom and 3 ft. wide at the top at gusset centre. The size of members will be: At tank face two steel channels, 10 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in.; at back, two angles, 5 in. by 5 in. by $\frac{3}{4}$ in.; tee struts, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in.; stiffening plate, $\frac{1}{4}$ in. thick; lattice bars and struts, $3\frac{1}{2}$ in. by $\frac{5}{8}$ in. flat; riveting, the same as for the third length.

The fifth length of the guide-framing will be the same as the fourth, but 3 ft. wide at the bottom and 2 ft. wide at the top. The sections of the members will be: At tank face two steel channels, 10 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in.; at back, two steel angles, 4 in. by 4 in. by $\frac{3}{4}$ in.; tee struts, 3 in. by 3 in. by $\frac{1}{2}$ in.; $\frac{1}{4}$-in. stiffening plates; lattice bars and struts, 3 in. by $\frac{5}{8}$ in. flat. The riveting will follow that for the third and fourth lengths.

There will be 24 cast-iron finials, 12 ft. high, as shown in Fig. 29. The metal will be of $\frac{1}{2}$ in. thickness throughout. A foot will be cast on so that the finial can be bolted to the centre plate at the top of the standards by four 1-in. bolts.

There will be five tiers of girders (Figs. 50 to 56, Plate I). Each girder will be about 28 ft. 6 in. long. The first tier will be 6 ft. wide, the second 5 ft., the third 4 ft., the fourth 3 ft., and the fifth 2 ft. (Figs. 39 to 44). One girder will have a steel chequered plate, $\frac{3}{8}$ in. thick, at the end in place of one pair of lattice bars, the $4\frac{1}{2}$-in. and $4\frac{1}{2}$-in. angle struts being riveted to it. A manway will be cut in this plate for a ladder to pass through.

Diagonal ties will be provided between each pair of girders and between the bottom girders and the base of the standards (Fig. 30). Each tie will be made in two parts, having an eye forged at one end and a screw at the other end for tightening-up. Each pair of ties will be attached to an octagonal forging, $4\frac{1}{2}$ in. by $1\frac{1}{2}$ in. section, 8 in. across, through which the screwed ends will pass with a nut on each side. The inner face of the four sides where the rods are screwed will be accurately machined. Cast-iron "stars" will be bolted to each side of the octagonal forging by four $\frac{7}{8}$-in. bolts to each pair. The sizes of the diagonal ties and pins will be as follow:—

Standards to first tier $1\frac{1}{2}$ in. diameter, $1\frac{1}{4}$ in. diameter pin, end $1\frac{1}{4}$ in. thick.

SHELL-HANDLING EQUIPMENT FOR A NATIONAL FACTORY.

CONSTRUCTED BY MESSRS. BABCOCK AND WILCOX, LIMITED, ENGINEERS, LONDON.

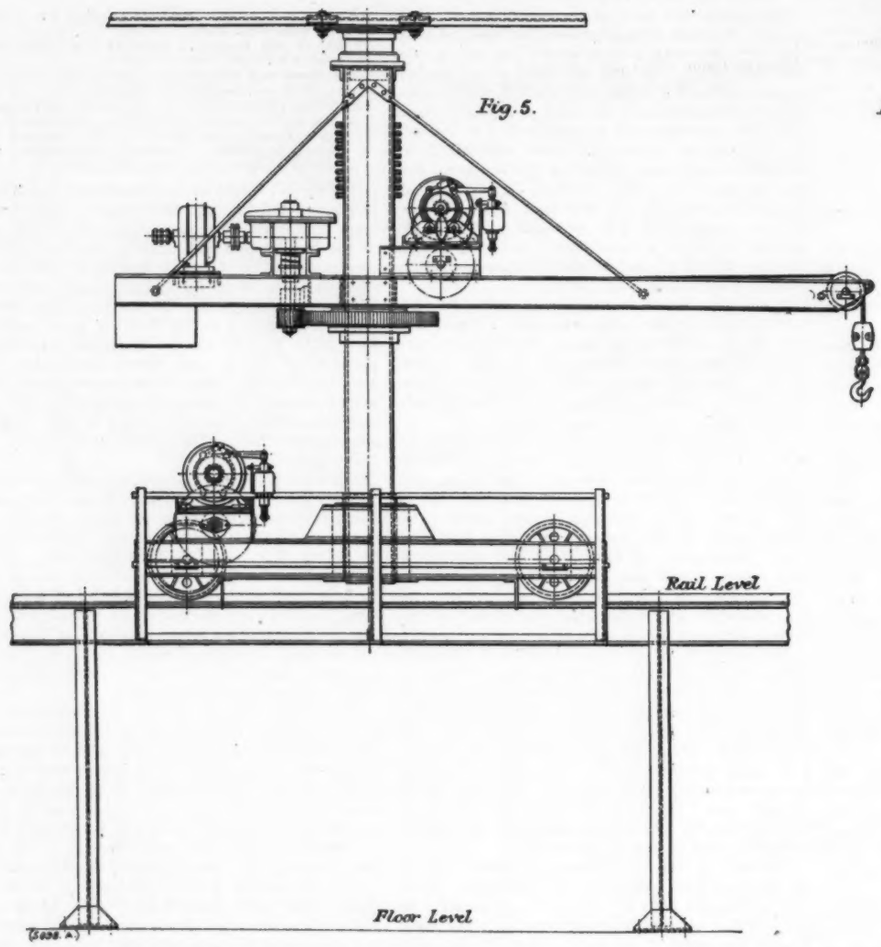


Fig. 5.

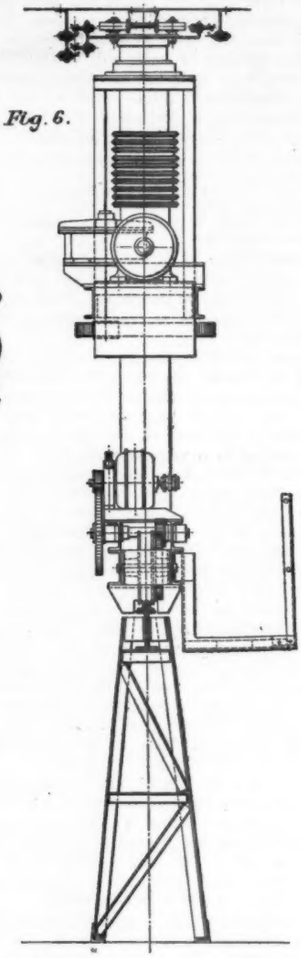


Fig. 6.

First to second tier, $1\frac{3}{8}$ in. diameter, $1\frac{1}{2}$ in. diameter pin, end $1\frac{3}{8}$ in. thick.
Second to third tier, $1\frac{1}{4}$ in. diameter, $1\frac{1}{2}$ in. diameter pin, end $1\frac{1}{4}$ in. thick.
Third to fourth tier, $1\frac{1}{8}$ in. diameter, $1\frac{1}{4}$ in. diameter pin, end $1\frac{1}{8}$ in. thick.
Fourth to fifth tier, 1 in. diameter, $1\frac{1}{8}$ in. diameter pin, end $1\frac{1}{8}$ in. thick.

The pins will be of mild steel and will pass through the tie-rods above and below the girders. Ladders and landings will be provided as indicated in Figs. 29 and 30.

Anti-freezing apparatus will be installed to prevent freezing of the water in the cups and tank. Live steam will be provided for this purpose, and two steam services to each cup will be fitted. The pipes will be laid in a covered wooden trough round half the circumference of the tank, and will be packed in with fossil meal.

Mr. Broadberry has specified with reference to material that the cast iron is to be of the best grey metal; test bars, 1 in. wide and 2 in. deep, are to be cast with each running, and must be capable, when placed on supports 3 ft. apart, of carrying in the middle a weight of 28 cwt., with $\frac{3}{4}$ in. deflection, without breaking. The wrought iron for the plates, rods, &c., must be capable of bearing a tensile strain of 23 tons per square inch of section with 15 per cent. extension in a length of 8 in. The rolled steel must possess a tensile strength of not less than 26 tons per square inch nor more than 30 tons per square inch of section, with elongation of 20 per cent. on a length of 8 in. Rivets and bolts to be made of Yorkshire iron of the toughest quality, the rods of which the rivets are made to bear a load of 25 tons per square inch before fracturing.

SHELL-HANDLING EQUIPMENT AT A NATIONAL FACTORY.

ON the present page, and on pages 11 and 14, we give illustrations of plant for handling heavy shells, which was supplied to an important national shell factory by Messrs. Babcock and Wilcox, Limited, of Oriel House, Farringdon-street, London, E.C.

The machine shop to which our views, Figs. 1 to 4, page 14, refer consists of two bays, each about 50 ft. wide and 400 ft. long. In each bay there are two rows of machines and two sets of gantries, carrying the travelling cranes by which the shells and billets are lifted and transported. These cranes are of the so-called single-rail type, the whole of the weight being, as shown in Figs. 5 and 6, transmitted to a single rail riveted to the I-beam which forms the top bar of the gantry. Tipping over is prevented by two pairs of rollers at the top of the crane post which abut against one side or the other of a rolled joist secured to the roof of the shop. The whole arrangement is clearly shown in Fig. 6. The top of the gantry is about 7 ft. above floor-level, and the space underneath is utilised for storing shells and blanks. Each crane has a jib of 10 ft. 6 in. radius, which is sufficient to extend to the centre of each line of machines served, and the cranes pass between the driving shafting and pulleys. The maximum load they are designed to lift is 15 cwt.

As will be seen from Figs. 5 and 6, the cranes are electrically driven, separate and independent motors being provided for the three operations of lifting, slewing and travelling. The controls are arranged so as to be operated from the small attendant's platform shown to the right in Fig. 6. The motors are of the slip-ring type, designed to operate with three-phase current supplied at 440 volts, the periodicity being 25 cycles per second. The hoisting and travelling motions are transmitted by ordinary spur gearing, and are fitted with the usual magnetic brakes. For the slewing motion worm reduction gearing is used, the worm running in an oil bath and a slipping clutch being fitted to take up any shock due to sudden starting or stopping.

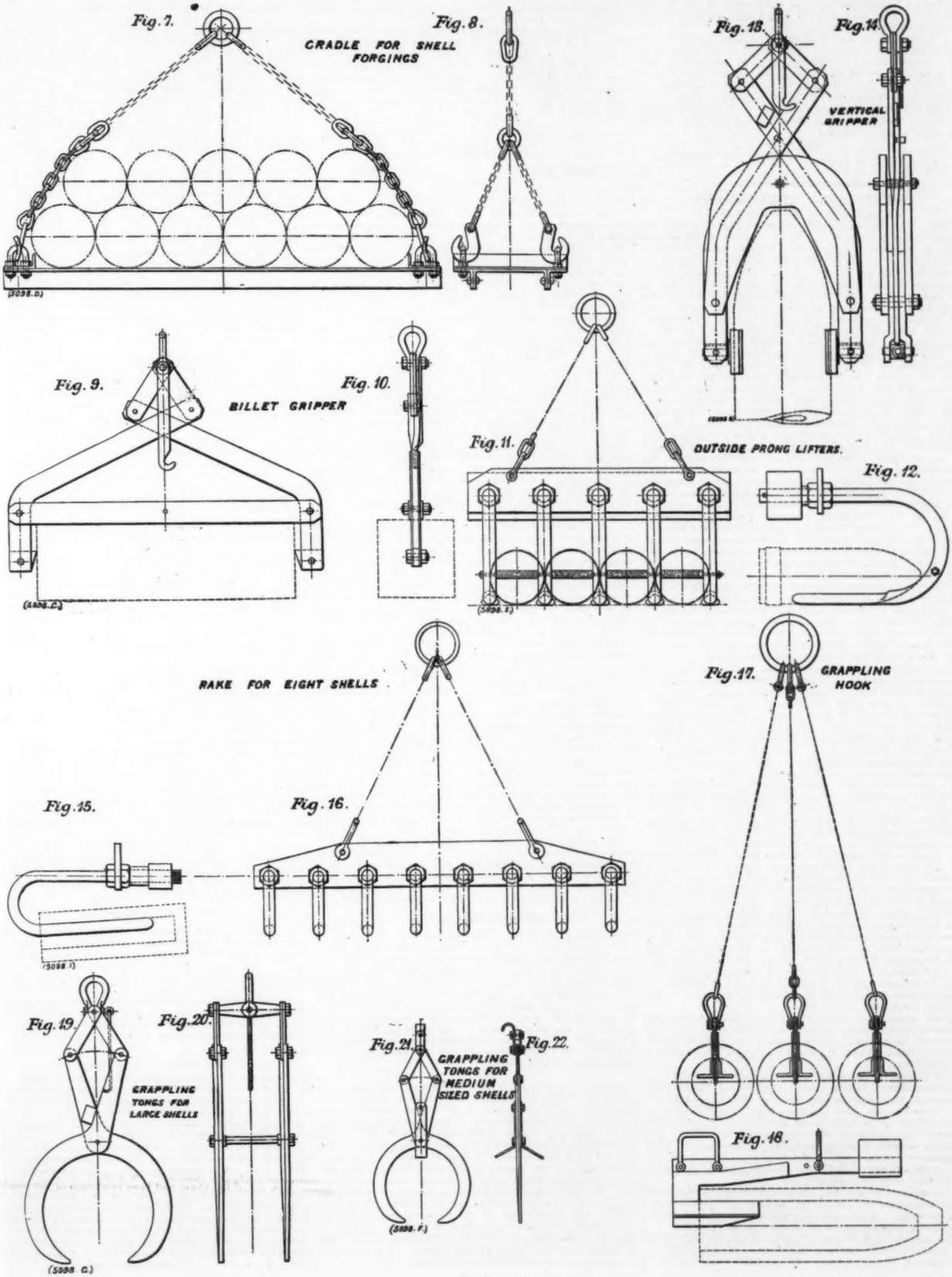
In view of the special character of the material to be handled the makers have designed and supplied various lifting tackles. In Figs. 7 and 8, page 11, we illustrate a cradle built up of inverted channel irons and fitted with slings, and designed to carry eleven 12-in. shells.

A gripper for lifting the unforged billets is illustrated in Figs. 9 and 10, whilst another type, intended for lifting heavy shells from the floor and turning them into a vertical position, is represented in Figs. 13 and 14. It consists of two heavy crossheads fitted with levers, which give a very powerful grip on the shell. The gripping parts are pivoted on the ends of the levers, thus allowing the shell to swing into the vertical position. These grips are lined with ferodo, to reduce the liability to slip.

An apparatus designed to lift from the floor four finished shells is illustrated in Figs. 11 and 12. The prongs are shaped to pass between an adjoining pair of shells, each of which is thus supported by two prongs. This device is shown in use in Fig. 3, page 14. For lifting the billets after forging the apparatus illustrated in Figs. 15 and 16 is employed. Its method of use is obvious. A similar system is used for handling shells at other stages of manufacture, as illustrated in Figs. 17 and 18. The tongs illustrated in Figs. 19 and 20 are suitable for lifting short shells up to 8 in. in diameter, whilst for larger shells the double tongs represented in Figs. 21 and 22 are employed. They are shown in use in Figs. 1 and 4 on page 14.

SHELL-HANDLING EQUIPMENT FOR A NATIONAL FACTORY.

CONSTRUCTED BY MESSRS. BABCOCK AND WILCOX, LIMITED, ENGINEERS, LONDON.



DRAUGHTSMEN AND FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—On reading the report of the meeting of the Manchester branch of the Association of Engineering and Shipbuilding Draughtsmen held at the Y.M.C.A. on June 9, I was interested in the speech of the general secretary, who said that it had been proposed in the near future to hold entrance examinations.

I would like to say that the proposed scheme is very important, and not until the Association of Engineering and Shipbuilding Draughtsmen have adopted it will their association be looked upon as of any great value. It is now time that this body of technical men began to make their advance, if ever they are going to do so.

I do not think that any technical body is blessed with a larger membership, and therefore the development of the association is assured.

Yours truly,
INSTITUTION ENGINEER.

Ashford, July 2, 1917.

GOVERNMENT EMPLOYMENT.

TO THE EDITOR OF ENGINEERING.

SIR,—The writer's experiences during a search for employment may possibly be of interest to those who have at any time engaged in a similar quest. Present conditions, to which this account relates, give, however, a special flavour to the story. The narrator is an engineer, 60 odd years of age, in the active pursuit of his calling—not a derelict—and, finding himself an idle man some twelve months since, began the great hunt. He began by entering his name at the Professional Classes Register, an adjunct of the Board of Trade Employment Bureau. One definite proposition was at once made by a very obliging official, but this, on being followed up, proved of but two-thirds the value that the writer was accustomed to under pre-war conditions, and was not accepted. Since then many letters have come from the registry asking if the applicant's name shall be retained on the lists. Many calls have been made, with courteous treatment always, but no results. The care taken of the writer's "papers" is admirable. On making a visit the messenger finds these in about three minutes—but in twelve months his principal is unable to find the required job. This department has lately been dealing with the professional applications of the National Service Registry, numbering many thousands—with what results?

Guided by wonderful arrows—pointing, pointing always—the writer found his way to the St. Ermin's Hotel, seeking information as to the significance of the undertaking required upon placing oneself, body and soul, in Mr. Neville Chamberlain's hands.

The lady who dealt with the question—a very pleasant person—gave the amazing explanation that this was a mere form, that the undertaking, though signed, carried no penalties if broken—the signatory could do as he thought fit about it. This is lovely! and appears to be in accordance with instructions, as advertised matter of the department, dealt with by an expert said to receive 750*l.* per annum, has declared the same thing.

Applications have been made to many Government departments—at one of these the gentleman interviewed leaned back in his chair and blandly asked, "Are you prepared to *give* your services to the Government?" and seemed almost shocked when a quite modest salary was named; yet the writer is cognisant of two cases in which civil engineers of undoubted ability, and over military age, being men of means, offered their services to a Government department without fee or reward, only to be turned down with terse refusal.

In one little-known department the applicant was asked by an official in khaki various questions relating to railway practice in the field, indicating a possibility of employment on outside military operations—winding up with the regretful admission, "But I am afraid you are somewhat too old." Applicant 62; interrogator 31. The business of seeking work has its compensations—you may find it, or, failing that, unearth a little gem of humour. In yet another department *the writer, being first approached*, was selected from thirty others and offered a position, acceptable as to terms and most desirable as to nature of the work, and at once closed, with a trifling reservation concerning status, contingent upon satisfactory work, which might easily have been adjusted. Having relinquished an appointment then held, he prepared to report at the proper time and place, to hear abruptly, the day before commencing duties, that the engagement was cancelled, and the writer was thus left stranded without employment, and as a result is out of pocket by about 80*l.*

Much experience of various employments justifies the writer in saying that he has never met such curt unhandsome treatment at the hands of any ordinary business firm. That is reserved for a Government department.

Still pursuing the search, in another department a billet was offered, but at a figure considerably below that common to the writer before the war, with the assurance that it would make him the most highly-paid civilian in the building—in a department needing on its staff men of excellent technical qualifications. Yet there are technical experts here—what is the explanation? This is apparently to be found in the large number of men one sees in khaki and navy blue—better money *is* paid: the civilian may have what is left.

It is said not to be a fair thing to criticise Government officials or service men, who, because of regulations, cannot reply. It sounds all right—but is also a most convenient dispensation and saves a lot of trouble.

The position is difficult; all ordinary engineering work not related to the war is stopped off. Of war work in Government departments, any position carrying pay suited to a man of experience in any way corresponding to his previous earnings appears to be reserved for men of military age, and frequently of military or naval rank. This suggests that possibly by seeking a commission the writer might be able to use his experience and draw adequate pay, but the idea of the civilian in khaki, masquerading as a soldier, taking the salute from fighting men, does not commend itself.

The writer has learned many things of late, not strictly relevant to the matter in hand. The amount of accommodation, *i.e.*, floor space, needed for Government work seems to be extraordinarily high. There are men working phenomenally hard—there are men working phenomenally little. In some departments there is much overtime made: a vicious system unless properly controlled.

Yours truly,
W. H. THORPE.

THE WHEELS OF AGRICULTURAL TRACTORS.

TO THE EDITOR OF ENGINEERING.

SIR,—It is interesting to note that the Local Government Board have found it necessary to pass a special order for the period of the war legalising the shape of wheel of the various agricultural tractors that are now being imported into this country.

I have always considered, from the start, that the ordinary Local Government Board regulations in reference to road locomotives were regulations framed in the true interest of both the road users and ratepayer, and, therefore, whilst the relaxation of these regulations at the present time, owing to the importance of getting a maximum number of tractors into use, seems necessary, it is to be hoped that after the war the old regulations willagain come into force, with possibly two alterations:—

1. That the weight resting upon a given wheel width might quite well be reduced and made more in favour of the road authorities without in any way being detrimental to the makers or users of agricultural tractors.

2. The minimum width of wheel allowed, I think, should be reconsidered, because the framers of the original act had in mind engines of some 10 tons in weight. It is quite obvious that light agricultural tractors of, say, 1¼ ton to 2¼ tons in weight should not be compelled to use the same minimum width of wheel as a 10-ton or 15-ton engine, but in no case need this minimum width bear even half as much weight as the original act provided.

Our Universal tractors are shod with the regulation 3-in. strakes on the rear wheel, and we have never found them mark or injure the road in any way; at the same time they will go into the field and do every kind of work that the farmer wants them to do in the way of ploughing, cultivating, threshing, carting and transporting the farm produce by road; a gripping attachment, of course, is provided for use in soft or wet fields. During the summer season it is seldom that we put anything whatever on the wheels of the tractor for general farm work.

Since 1902 I have tried every form of grip and tread that I could conceive, and I have found nothing so good as the regulation strakes already permitted by the authorities, but I do think that the Local Government Board might reconsider the question of the minimum width of wheel for these light machines. I especially allude to the band on the front wheel. I think that if a 10-ton or 15-ton engine may use a band on the front wheel 5 in. wide, that an engine, say, one-sixth in weight might use a band 2 in. wide. This band is very useful on an agricultural tractor. It never marks the road, owing to the light weight upon it, and when in the field it cuts into the soil (until the broader wheel supports the remainder of the weight) and prevents side slipping.

There is no suction from these straked metal wheels as is the case with rubber-tyred road lorries, and in roads where they are continually used I have always found them improve the road instead of injuring it. Their broad wheels and their light weight are insufficient to crush the metal, and they have the effect of rolling it in.

Yours faithfully,
H. P. SAUNDERSON.

Elstow Engineering Works, Bedford, July 4, 1917.

AMERICAN BAUXITE.—The production of bauxite in 1916, says *The Iron Trade Review*, Cleveland, Ohio, was 425,359 long tons, valued at 2,297,825 dols., an increase of 43 per cent. in quantity and 52 per cent. in value over 1915. This is a notable increase for the whole United States, but the most striking figures are those for Georgia and Alabama, in which the production of bauxite was increased from 25,008 long tons in 1915 to 46,410 long tons in 1916, a gain of 86 per cent. The production in Arkansas and Tennessee was increased from 272,033 long tons in 1915 to 378,949 long tons in 1916, a gain of 39 per cent.

TECHNICAL JOURNALS FOR THE ARMY.—On page 554 of our last issue we inserted a request made by *Motor Traction*, 20, Tudor-street, E.C. 4, and Coventry, for technical journals to be sent to our troops at the front. *Motor Traction* states that the scheme has proved eminently successful, and they are now assured of being able to send out a large parcel of papers each week, made up from the copies of technical, engineering and motor journals which they have received. The officer who has undertaken the distribution has expressed his thanks for the way in which the demand has been met, adding that "in view of the very large number of motor transport units in France, it will be difficult to send too many papers." *Motor Traction* will be glad to receive for the same purpose further back numbers or current numbers which can be spared.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With the near approach of the holidays a feverish anxiety prevails in every Government-controlled steel-making establishment in the West of Scotland, and herculean efforts are being exerted to get all the orders in hand executed and put out before the works shut down. The demand for all classes of steel material is urgent and insistent, the entire production being utilised, either directly or indirectly, on Government account. This extraordinary industrial activity, rendered necessary for the proper prosecution of the war, is pushing the ordinary home and export trade further and further into the background, the only steel which is leaving the country being some shipments to France. Every mill is running, and steel bars, mercantile and shipbuilding requirements are being turned out with all possible speed and in largely increasing quantities, what the Premier described as "The battle of the Clyde" occupying the entire attention of both employers and employees. "If employers and workmen pull together," said Mr. Lloyd George, "and pull with all their might, between them they will pull us through." The activity in the shipyards would itself in normal times keep every steel works in the West of Scotland in constant employment, but meantime this is only an integral part of what has to be accomplished. Home prices are still fixed and unchanged, but export rates are fairly stiff.

Malleable Iron Trade.—During the week nothing new or fresh has occurred in connection with the malleable iron trade—the conditions of labour and output still being on a large and elaborate scale, with makers pressed on every hand for delivery of the more urgent orders. So extensive is the nature of the Government work being dealt with at the moment that the claims of ordinary mercantile consumers can only be considered in a restricted measure, the steel products being as much in demand as the iron.

Scotch Pig-Iron Trade.—The demand for pig-iron of all grades keeps so exceptionally strong that, although a high average of output is being well maintained, makers cannot conceal the fact that there is urgent necessity for them endeavouring to augment this if at all possible. Certain brands of foundry and forge iron are decidedly scarce, and the great demand for hematite continues. Every conceivable effort is being put forth to conserve the supply for the requirements of the Allied Governments, with the result that little is obtainable for the export trade.

Blast-furnacemen's Demands.—For some time past blast-furnacemen in the Coatbridge district have been clamouring so persistently for double time for Sunday work that it was decided to refer the matter to arbitration. The finding of the arbiter was that, after a full week's work, time and a quarter should be allowed for all Sunday labour. As this decision was not favoured by the men, they intimated on Saturday night that they would not work over the week-end. Similar intimation was made by the men employed at Shott's Ironworks, failing concession of their demands.

New Shipyard Regulation.—The new regulation respecting the presence of enemy aliens in shipbuilding yards without permission in writing from the Admiralty or the Shipping Controller, just issued under the Defence of the Realm Act, comes at a time when the subject of alien enemies is once again causing some considerable stir in Glasgow, particularly in business circles. This latest restriction, which undoubtedly should have been enforced long ago, renders it "unlawful for any person being the owner of a ship, or employed as a ship's agent, shipbroker or ship's husband, or as an inspector or surveyor of ships or their machinery, if he is not a natural-born British subject, or if his father is or was at any time the subject of a State at war with His Majesty," to enter the precincts of any shipbuilding yard in the country without written authority. Power to act summarily is thus given, and it is to be hoped that the safeguarding of the nation's interests, so far as the building and equipping of ships is concerned, will be thoroughly accomplished.

PERSONAL.—The American Steel Export Company announces the appointment of Mr. F. H. Tackaberry as travelling representative with the title of general agent. Up to the time of the outbreak of the disturbances in Mexico he was the representative of the Pennsylvania Steel Company in Mexico City, and later the assistant general manager of sales for that company. Mr. Tackaberry's first trip will be to South America, Brazil being his immediate objective and Rio de Janeiro his first base of operations.

MAGNETIC AND TITANIFEROUS SANDS.—In our issue of February 16 last, page 167, we called attention to the formation of a company for smelting the magnetic and titaniferous ironsands which were found at Taranaki, near New Plymouth, New Zealand. We have just received a letter, dated April 28, from a correspondent there, who said that although the works were not started at that date the next fortnight would see them going, as there had been trial runs of the machinery and everything went off successfully. The experimental part of the process was carried on at the old works, and the new works were placed right close to the beach where the ironsand collects. The shipping facilities for home liners are within a quarter of a mile from the works, and are connected by a private siding with the New Zealand Government lines right to the wharf. A few samples of the sand have been sent to Lancashire, each containing from 54 per cent. to 61 per cent. of iron.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Chief interest in the position in this area centres in the attempts that are being made to obtain supplies for stocking purposes. Works are trying rather strenuously to secure extra deliveries, but the large character of the general demand is against them, and the open market has nothing to offer in the way of substantial tonnage. There are certain stocks held in reserve at the works, but whether these will meet the needs of the next winter emergencies is a matter which time alone can supply the answer to. It is now fairly well established that nearly all the important contracts have been renewed, with the terms slightly in favour of the collieries. Export deliveries are on a smaller scale than for some time past, this being largely accounted for in the diminished trade with neutrals. Munition works, railways, and other industrial undertakings are in the market for full supplies of best steam hards. Nuts are wanted in heavy quantities, and cobbles sell with the utmost ease. There is also a good trade for gas nuts. Slacks remain tight, with the principal demand from the Lancashire works. The inquiry for all grades of coke is of the strongest, and values remain at the utmost limit. House coal orders show no signs of falling away, and dealers and merchants are confronted with a difficult situation. Quotations :—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—It becomes more patent every day that the acceleration of the production of basic iron, essential as it was, has only been obtained at the expense of the foundry and forge sorts, and the position to-day for the two latter brands is one of tightness. The supplies of foundry iron coming into the market are very short, and the result is that there is something like a run on them. It is not surprising to find that the opinion of the Derbyshire makers is that the market inquiry is now quite high enough to justify the advance in the tariff for which they have been long petitioning. On the other hand, there is a solid body of opinion that present prices are high enough, and should in no sense be exceeded if consumers are to be expected to work at anything like an economical figure. Derbyshire makers are in a favourable position, for Lincolnshire brands are only coming to hand slowly, owing to the difficult works alterations in progress. The tonnage of both east and west coast hematities is not as satisfactory as could be desired, but there is cause for gratification in the quantity of basic iron which has been made available under the new scheme of the Ministry of Munitions, and this brand is being used for others not so readily to hand. Another important factor is that more Swedish material is now arriving on the market, though this is somewhat discounted by the extravagant figures quoted at Gothenburg. Swedish bar iron is offered at 40*l.* to 45*l.* f.o.b., this being many times the pre-war price, and renders it unprofitable to consumers except for the very highest class of work. Swedish steel billets are as high in proportion, but they are meeting a good sale. Rolling-mills are fully employed, and it is almost useless to take work to them without the full complement of Government certificates, priority orders, &c. The briskness in marine work, which we have noted from time to time, is still to be found, and, from what we are informed on reliable authority, it will become more and more important during the progress of the present year until it occupies more time and attention than anything yet undertaken by the local works. There is a feeling going the rounds of the local establishments, not altogether unsupported by facts, that Sheffield works will become more concerned with shipbuilding work than they have ever yet been in their history. It is difficult to get full details of the scheme which is undoubtedly on foot. Tool makers are also directly interested in the shipyard activity, and are responding to the call for further parcels of high-speed and carbon cutting tools to the utmost of their capacity. Happily there seems to be an ample supply of tungsten. Files are wanted for Admiralty yards, and saws for work both here and with the forces. In the lighter sections of the trades the cutlery firms find that orders are to be had without the asking, but that the labour and material problems prevent them from accepting all the commissions. Plate requirements are on a large scale for export, but the home trade is now small. From overseas there is a consistent demand for tools, saws, files, anvils, mining machinery, roller bars, knives, farm implements, colliery plant, high-speed steel, plate and cutlery.

SEPARATION OF THE ISOTOPIC FORMS OF LEAD.—According to Soddy, Fajans and others, the various forms of isotopic elements are not separable by chemical means. Such assertions require a good deal of support. Recent researches by T. W. Richards and N. F. Hall (Journal American Chemical Society, 1917, pages 531 to 541) confirm that the lead isotopes are certainly not separable by a long and elaborate series of crystallisation processes. They started from Australian carnotite containing, as they knew from previous researches, 1 part of ordinary lead, 3 parts of radium G and a trace of radium B. These three leads, together 1 kg. of metal, were converted into nitrates and recrystallised more than 1,000 times; but the first and the final products did not differ as to their atomic weight of the metal and its β-radioactivity. The solubilities of the three nitrates must be the same, therefore.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron has been fairly active. The very liberal July allocations to home consumers have resulted in arrangements for good supplies over the month, but Scotland is taking less iron in consequence of the approaching Glasgow holidays, and some of the home foundries, not directly concerned on certain work, are not so keen for deliveries as they have been in recent previous months. There is nothing doing on forward account, buyers having no inducement to place orders ahead. A fairly large Continental business is passing, mostly with France, and with tonnage facilities improving shipments to our Allies promise to be heavier. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*, though some makers with rather considerable stock of forge iron are understood to be still selling that quality at a little below the recognised market rate. For shipment to France and to Italy No. 3 Cleveland pig-iron is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

The Warrant Stores.—The stock of Cleveland pig-iron in the public warrant stores is lower than it has ever been in the history of the stores, and it would cause little surprise if at any time it disappeared altogether. During the month of June 515 tons were withdrawn—500 tons on the 7th, 8 tons on the 11th, and 7 tons on the 25th—thus reducing the quantity held to 1,358 tons, all of which is No. 3 quality. There are now warrants in circulation for only 1,250 tons of Cleveland pig.

Hematite Iron.—The East Coast hematite branch of trade is very strong. Heavy home requirements continue to receive adequate attention, and the strict official distribution not only meets all legitimate needs, but leaves some surplus available for sale abroad. In one or two quarters there is less disinclination to do foreign business, but the prevailing feeling of uncertainty with regard to prices in the near future for iron destined for other countries still hampers export transactions. Against old contracts, however, shipments are proceeding fairly well, and with promise of more tonnage dispatches should be heavier. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use; whilst for shipment to France the market quotation is 137*s.* 6*d.*, and for export to Italy the recognised rate is 142*s.* 6*d.*

Manufactured Iron and Steel.—No material change is perceptible in the manufactured iron and steel industries. Government needs and the requirements of the shipyards continue to take up nearly all the output, with the result that little ordinary commercial business is passing. Quotations all round are very firm. For home use common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 14*l.* 10*s.* to 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Shipments of Iron and Steel.—Returns for June give the total shipments of pig-iron, manufactured iron and steel from the port of Middlesbrough at 81,390 tons, as against 93,280 tons for May. Loadings of pig-iron last month reached 60,638 tons—an increase of 723 tons on May, and the largest since August last, when the clearances amounted to 63,635 tons. Manufactured iron shipped in June amounted to 3,798 tons and steel to 16,954 tons—a total of 20,752 tons, as compared with a total of 33,315 tons for the previous month, but the total clearances of manufactured iron and steel during April were only 20,232 tons.

THE INFLUENCE OF ORGANISATION ON HISTORY.—The British Empire Producers' Organisation, of Kingsway, London, W.C. 2, has issued a pamphlet, which is apparently the reproduction of a lecture by Mr. Ian D. Colvin, entitled "The Influence of Organisation on History." This publication reveals a little known state of affairs in the Middle Ages. In those days the Hanseatic League, a union of 70 German cities, the chief of them being Lubeck, Hamburg, Bremen, Dantzig and Cologne, were the strongest single commercial and political factor in Western Europe. They had the monopoly of timber, hemp, pitch, turpentine, flax, wax, salt fish, and the metal trade, and by menace and bribery they enjoyed immense political power. They assisted to destroy Simon de Montfort; in the wars of the Roses the Hanseatic Fleet played an important part, and the league replaced Edward IV on the throne. England was the wool farm of the Hanseatic League, which extorted preferential terms from the sovereigns, both as to export and import. It was not until English merchants, under Sir Thomas Gresham, organised themselves into the Worshipful Society of the Merchant Adventurers of England, in the reign of Edward VI, that the German control of our markets was broken. We have not space to follow the steps by which English merchants and manufacturers turned the tables and became the commercial rulers of Germany up to 1840. The moral of it is that a nation achieves the greatest things in history when its economic and political power are in the same hands. Much of the information in the pamphlet is quite new to us, and we have no means at hand of verifying it, but, in spite of some exaggeration, it is well worth the consideration of those who are seeking new methods—or the restoration of old methods—to meet the conditions which face us.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Almost completely stagnant conditions prevail on the coal market this week, and grave fears are entertained as to the immediate future of the trade. Although the scarcity of tonnage is doubtless the main cause of the present severe depression, the situation is greatly aggravated by the Controller of Mines' new schedule of fixed prices, inasmuch as no one seems to know how the scale will work out in practice. So complicated has become the situation, indeed, that the opinion is expressed that the new scheme may be found impracticable, and that some other artifice will have to be adopted if the Coal Controller continues to insist in his scheme to give the market a direction so contrary to that determined by actual conditions. This is, perhaps, a somewhat pessimistic view to take, for every effort will be made to carry out the scheme. Middlemen do not seem to have yet received any definite instructions as to the prices to be charged to neutrals, and for the moment they are in a quandary as to the future conduct of their business. Nevertheless it was only to be expected that the introduction of such an entirely new method of trading would, at least temporarily, have a disturbing effect. Under the old order buyers would now be able to obtain parcels for spot, or this week's shipment, at about 26*s.* to 27*s.* for Admiralty steam coals, and probably smalls at anything from 16*s.* downwards. Colliery salesmen, however, are quoting the new schedule figures without any qualification, except perhaps in regard to bunkers—the position concerning which is still obscure—and the Controller's schedule is anything from 5*s.* to 6*s.* above competitive figures. Moreover, the unsettled state of the classification list is also proving a restraint on business, and no one can say how the list will work out in practice even when it is completed and published. Pitwood is steadier at 70*s.* to 72*s.* 6*d.* There is no market for patent fuel, but French contractors for small coals are reported to be pressing for the deliveries of arrears.

Newport.—The supply of tonnage is better, but the amount of shipping in the dock is barely sufficient for the needs of the collieries. The new fixed prices are being quoted as a matter of form, but no business has taken place, and the indications are that the market will take some considerable time to adjust itself.

Classification of Coals.—The work of classifying coal to conform with the new schedule of fixed prices is proving a very difficult task. For two days this week the committee appointed by the Monmouthshire and South Wales Conlowners' Association have been dealing with the matter, but their work is still uncompleted, and further consideration has been deferred until the end of the week. Though no report has been supplied, it is stated that the committee have been unable to accept the classifications in many instances, particularly those of Monmouthshire coals. Of course in its final form the list as agreed upon by the committee will have to be submitted for the approval of the Coal Controller. But even after classification it is understood that it will be open to dissatisfied colliery owners to appeal against their particular classification. In the meantime the position generally is disconcertingly indefinite,

FACTORY LIGHTING.—At a recent meeting of the Chicago section of the Illuminating Engineering Society Mr. Ward Harrison described the results of an investigation into the lighting of factories. He found that with daylight lighting the average intensity of the light was far below the values observed very near to windows, which are the figures commonly quoted when comparing natural and artificial lighting. Values of several hundred foot-candles may be found near windows when the actual values at the places where work is in progress may be from 1 foot-candle to 20 foot-candles. With modern lamps artificial lighting equal to this can be very cheaply achieved. In some respects the artificial light is superior to daylight, as it can be distributed more uniformly, though it is inferior in diffusion and freedom from glare.

DANGERS OF ACETONE-AIR MIXTURES.—In investigating the industrial conditions under which the vapours of inflammable liquids form explosive mixtures with air, Drs. R. V. Wheeler and A. Whitaker deal, in the account of their first research presented to the Chemical Society (April number of the Transactions), with acetone. This material is largely used in cordite manufacture, and rapid air currents may pass through long mains charged with acetone vapours. Laboratory methods have so far been used, because, acetone vapour being soluble in water, glycerol, brine, &c., the vapour-air mixtures must be stored over mercury, and the apparatus must be kept thoroughly dry. Experiments on the higher and lower limits of inflammability of the mixtures were made in tubes 2.5 cm., 5 cm., 10 cm. in diameter, and 60 cm., 150 cm. and 75 cm. in length, for horizontal, downward and upward propagation of flame. When the diameter exceeds 5 cm. the pipe size influences the inflammability limits little, and it is concluded that the lower and higher limit would, for horizontal propagation in large pipes of about 60 cm. diameter, be 2 per cent. and 10 per cent. of acetone vapour. The speed of flame propagation was determined for the "uniform movement" of the flame, which we explained in describing Wheeler's previous experiments on mixtures of methane and air, though it is known that this uniform movement is only observed in tubes of small diameters. In the 2.5-cm. tube this speed attained a maximum of 96 cm. per second in mixtures containing 5.5 per cent. of acetone. For pipes of 30 cm., 60 cm. and 90 cm. diameters these speeds would probably be 2.5, 3 and 3.5 times as great. The quantity of acetone required for complete combustion of the oxygen in air would be 4.76 per cent.

SHELL-HANDLING EQUIPMENT FOR A NATIONAL FACTORY.

CONSTRUCTED BY MESSRS. BABCOCK AND WILCOX, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 10.)

FIG. 1. HEAVY SHELL BEING LIFTED BY DOUBLE TONGS.

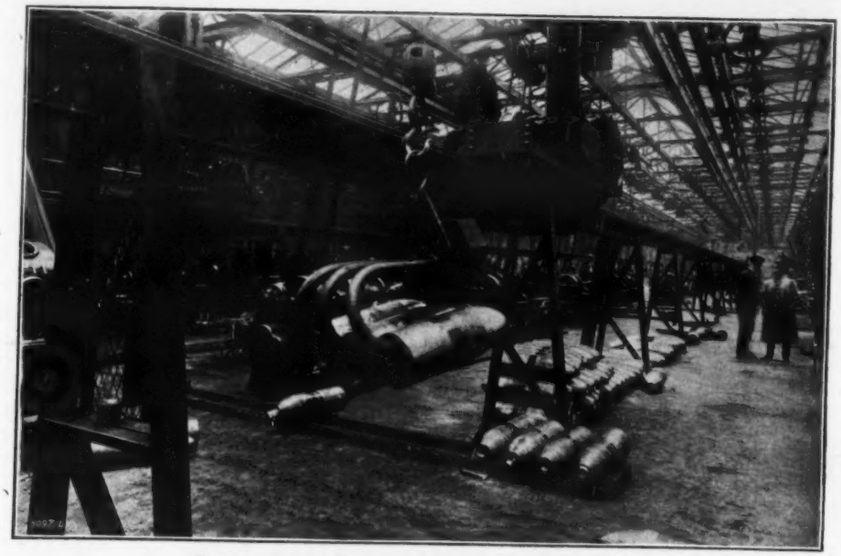


FIG. 2. THREE UNFINISHED SHELLS ON HOOK LIFTER.

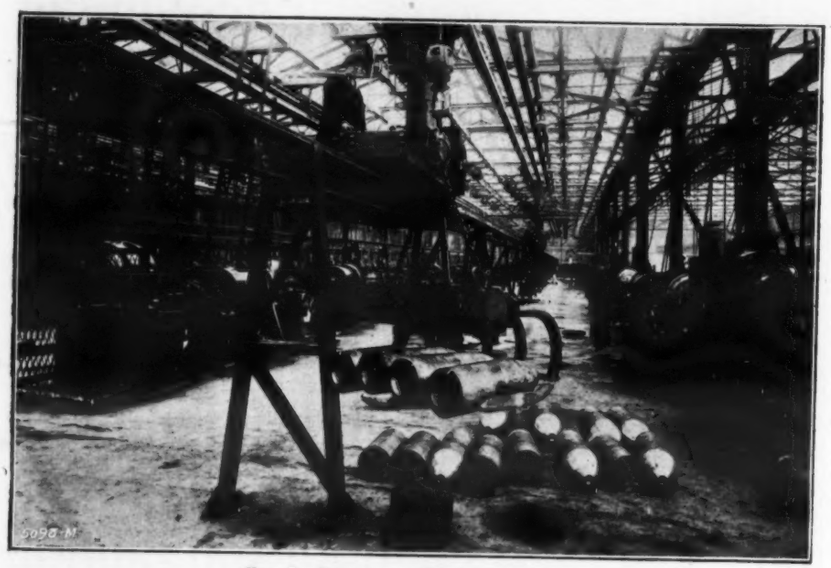


FIG. 3. LIFTER FOR FINISHED SHELLS.

FIG. 4. HANDLING FINISHED SHELLS.

GASHOLDER FOR THE EXTENSION OF THE WORKS OF THE

MR. A. E. BROADBERRY, INST. C.E.

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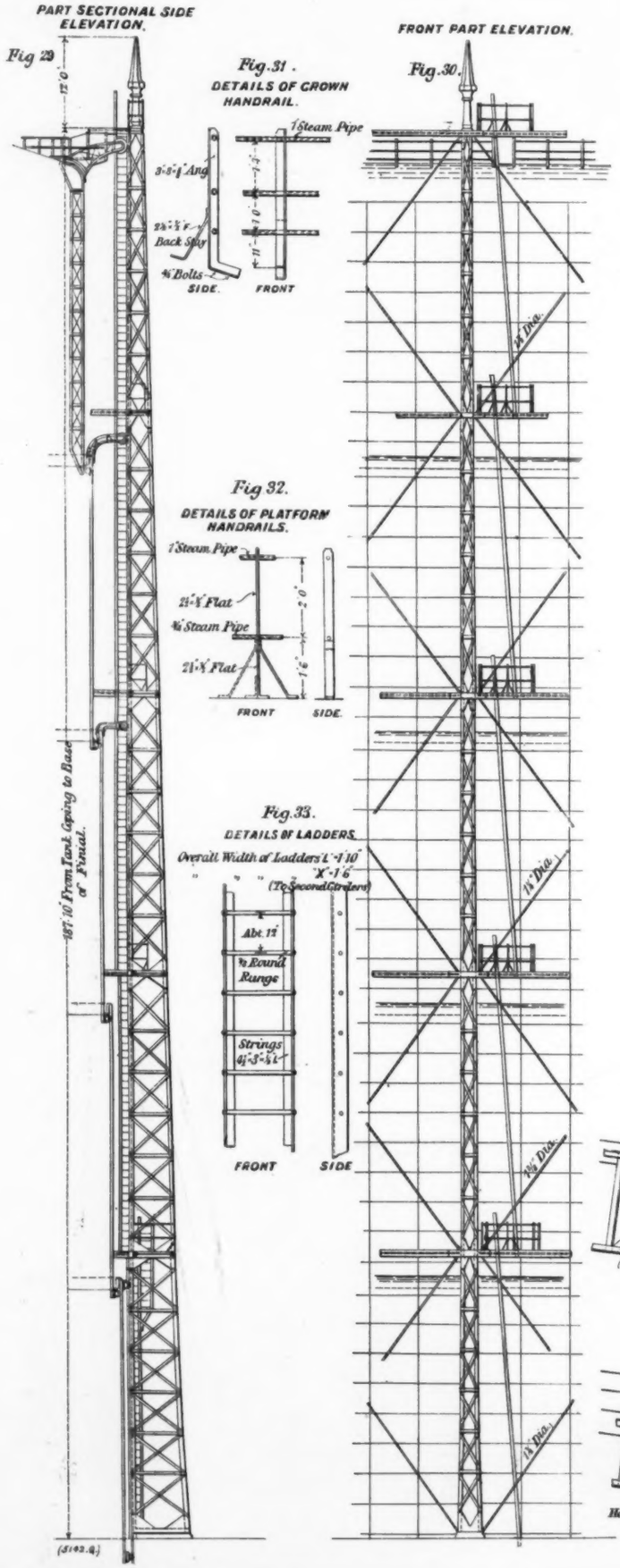

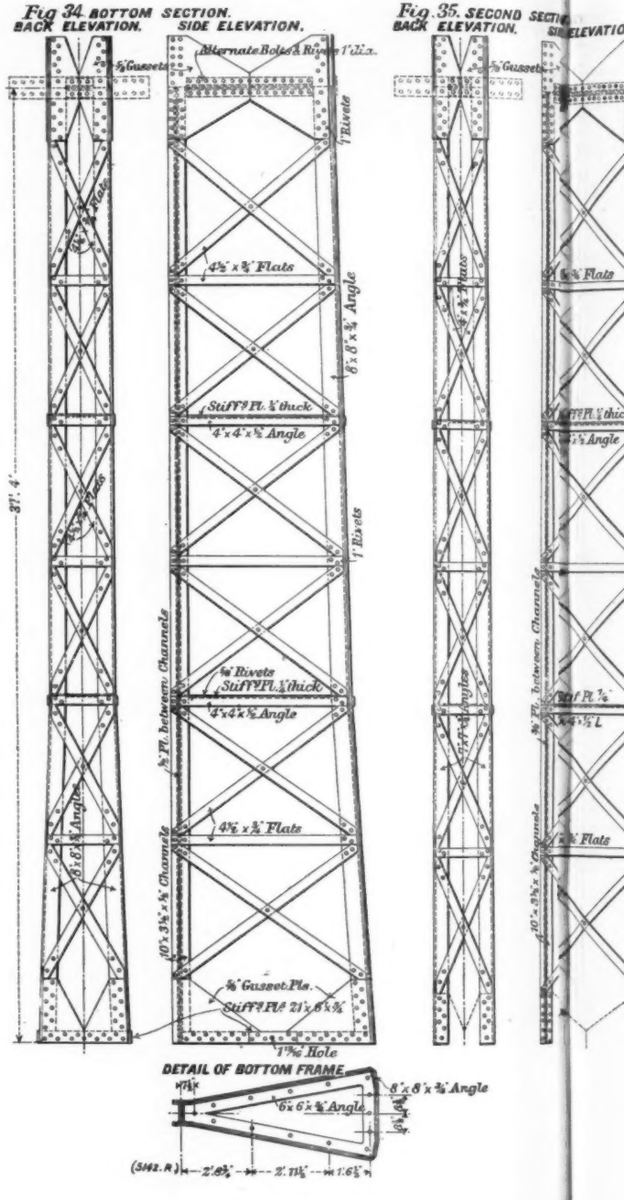

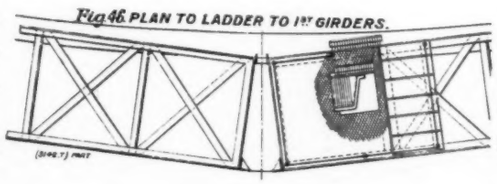

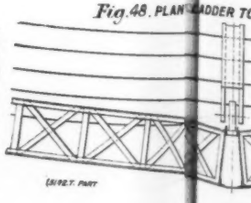

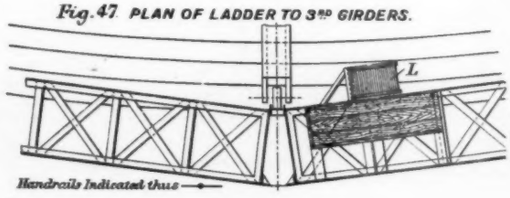

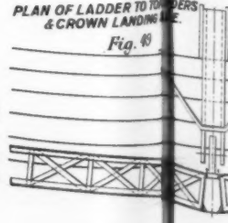

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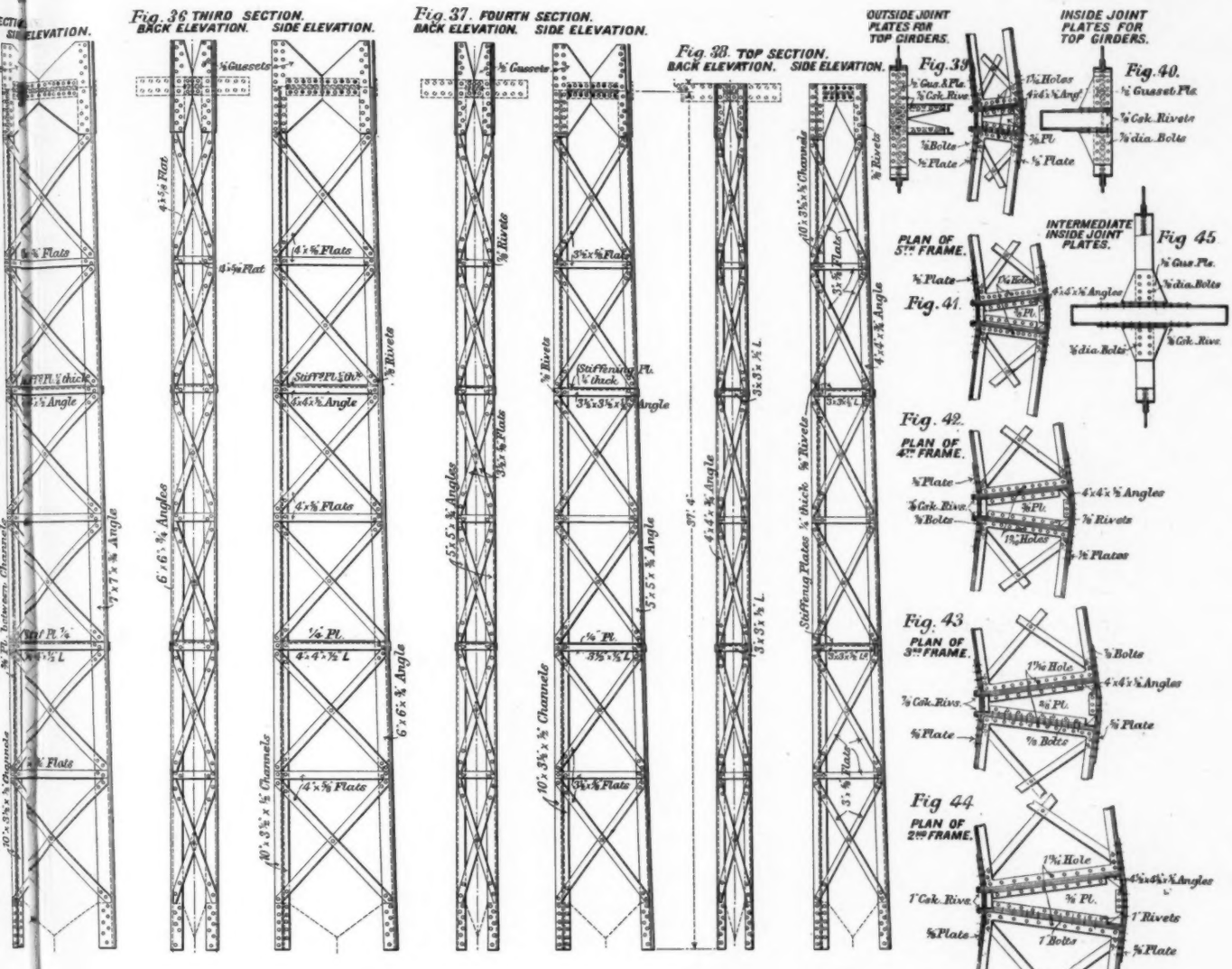

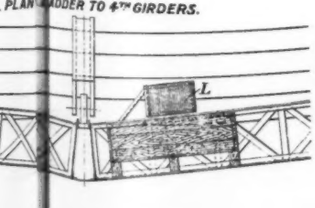

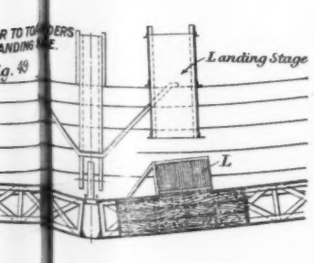

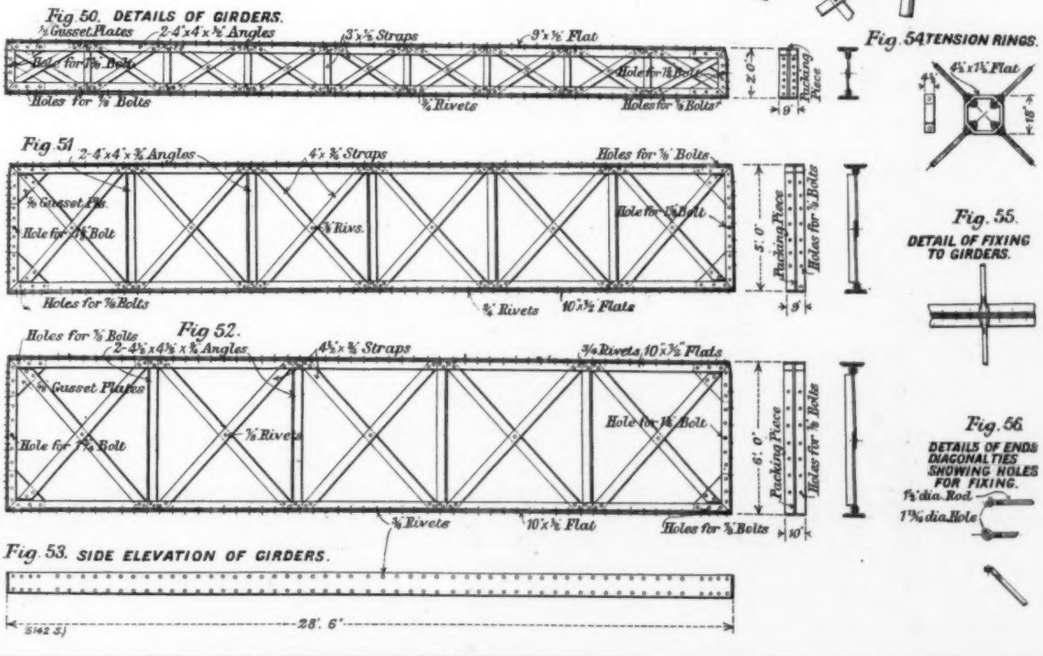

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the GASHOLDER FOR THE EXTENSION OF THE WORKS OF THE TOTTENHAM LIGHT, HEAT AND POWER COMPANY.

NOTICE OF MEETING.

THE ASSOCIATION OF MANAGERS OF SEWAGE DISPOSAL WORKS.—Saturday, July 7, at 11 a.m., at the Guildhall, Worcester. Presidential address by Dr. Sidney Barwise, B.Sc., followed by a paper on "The Activated Sludge Process of Sewage Purification," by Mr. Thomas Craink, Assoc.M.Inst. C.E., City Engineer. In the afternoon there will be a visit to the sewage works.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 6, 1917.

THE STATE ADMINISTRATION OF ENGINEERING INDUSTRIES.

IN the debate on the Munitions Vote a note was struck that is now familiar when any official voice is raised on behalf of the Ministry. It sounded the vastness of the enterprise; its small beginnings, the factors by which its output was multiplied at various epochs, its innumerable staff. The Minister once again was proclaimed the largest employer of labour in this or any other universe; the conception of the Ministry an inspiration on the part of its only begetter; its administration a prodigy of executive skill. If hard-worked Ministers can derive satisfaction from contemplating the facts so reflected in a convex mirror, it would be ungracious and impolitic to grudge them the recreation.

But at the same time it is of some importance not to lose sight of the undistorted image of this great undertaking; for the facts in their true perspective, though Ministers or their advisers may really have a more accurate view of them than they present to the public, can easily escape the notice of those who are less well informed. The order of magnitude of production may perhaps be estimated more or less nearly. Official figures are available for the numbers employed. But it is questionable whether any man, official or not, can do more than guess at the efficiency with which the Ministry's business is conducted. That constant complaints are heard of work being held up for lack of supplies, of delays occurring for no apparent reason, of decisions taken and cancelled and retaken, is by no means conclusive of inefficiency. Where one such incident happens, it will attract attention; while business of many thousand times the volume, if it is conducted without a hitch, may pass unnoticed. But this unquestionable fact, which is not likely to be overlooked so long as a Parliamentary representative of the Ministry has access to a public platform, is even less conclusive of the efficiency of the system. The figures, if they exist, are not available, and cannot yet be put in; but there are broad facts which create a *prima facie* presumption that considerable inefficiency has occurred in matters in which it could have been avoided almost from the outset. A very little trial with a few honest machinists would have shown the responsible authorities by what sort of amount the piecework prices current at the inception of the Ministry would have increased men's earnings; and very little of the uncanny imagination and insight that is credited to the founder of the Ministry would have been needed to tell him, if the staff at his disposal had been unable to do so, that proper minimum outputs should have been attached as a condition of paying current piecework rates instead of such as would stand in a more usual ratio to daywork money. The edge, again, of the grotesque extravagance in overtime which was insisted on, not merely at the outset but almost for years afterwards, was doubtless taken off by the forethought which allowed time to be lost in ordinary hours and money made up by working overtime. But it is certainly not to be assumed that all workers put in their time with that sagacity; and for those who worked full time any man who knows what work is and what men's strength could have told the Minister at once, as he has since found out, that in a great deal of work to keep such hours up month in month out could be done only by sacrificing output.

These are general considerations, and no numerical inference can be drawn from them as to the efficiency of the Ministry. Two facts, however, must be remembered when what may be called its handicap is considered. If it is regarded as the employer of the labour that it controls it has been its own largest customer, and a customer whose orders, both in size and regularity, were beyond anything within previous manufacturing experience. It is apt, again, and quite rightly, to claim the indulgence due to youth; but when this claim is made it must not be forgotten that it has had ready-made extraneous assistance that is beyond any precedent in the oldest department in this country. In every branch of industry in which such help could be of use it has been given ungrudgingly. All the experience and the skill and the personal character that had accumulated in British engineering industry, and some that was imported from the other side of the Atlantic, joined up as fast as it was asked to help the Ministry out with its enormous task.

Facts such as these are not always remembered, or viewed in the commanding perspective to which they are entitled; and as a result of the oversight the aspiration is heard sometimes that industry would benefit if the benevolent control that the State now exercises over industry while it is engaged solely on national work were continued when war is over. While the effect of the convex mirror is merely to distort the picture of the present, and the original is not affected by the travesty, no great harm is done. We are, so to speak, in for it; we may be working efficiently or we may not; but if only the Government will produce what we need in munitions and men, efficiency is a matter of secondary importance. But though this may be the case in war, it will be the exact reverse of the case in peace. We shall not meet our vast external obligations and pay our way merely by taking in the State's washing at extravagant rates. Either we shall need to conduct our industries efficiently, or we shall be left without industries to conduct. The vast plant that will remain when the war is over will not by itself find the country the price of a quartern loaf. Either it will have to be worked efficiently so as to earn at international rates and under international conditions the profit out of which alone the price of the loaf will come, or it will have to be broken up and sold as scrap. To work it inefficiently would be merely to pile up debt.

When, therefore, it is sought to infer from the vast scale of the nation's present manufactures the possibility of a similar output in times of peace, engineers must look very soberly at the facts before they jump at conclusions. They must realise that as yet, in spite of the collaboration of all the business talent in the country, no public evidence is available to show that the business of the Ministry is being conducted with what would commercially be considered efficiency; that is to say, with the same proportionate yield for energy expended as is obtained by the best other manufacturing nations. But assuming for the purpose of argument that it is being so conducted—and it is indeed a wide assumption—no suggestion is made of how the efficiency is to be maintained when the multiplex demands of peace are substituted for the relatively simple calls of war. It has been naïvely suggested that industry is made up just of so much material, and so many men and women, and the rest is merely book-keeping; that so long as these continue to be available and the product is enough to keep, house, and clothe all parties, industry can continue to be conducted by the State for the

State's benefit. Two facts are overlooked in this ingenuous reasoning. To-day our only product is death and desolation, and the cost of production is paid by the State; but in ordinary times the material to be worked up can be had only if it is paid for out of the proceeds of the product. The material, again, will neither work itself up, nor fit itself to the needs of customers, nor sell itself. To these indispensable ends go the labour of men and the skill of management. And how are these to be brought to where they are wanted? Previous experience hardly suggests that it will be done by a centralised bureaucratic control, the standards of which must necessarily be stereotyped and inelastic as no standards have been hitherto in prosperous industry. The co-operation of the State with industry, like the mutual co-operation of the agents of industry, can do much to the common end; but past experience shows it can be successful only when it is used to help live individual enterprises.

It is a mere commonplace of any evolution to say that progress occurs only through a diversity of individual characters in the organisms from which the stock is derived. That is precisely what even the best centralised control must sacrifice. Its measures and standards must always tend to be a compromise; adapted, it may be, to the needs of the average case, but crippling the development of the exceptional case, on which industry has in a great and essential degree to depend for progress and initiative. We want now more than ever the closest possible fit of individual effort and individual incentive to the circumstances of each enterprise. We have to replace our war manufactures by others which must largely be new. To fit these aptly to the multitudinous needs that we shall have to satisfy if our output is to be acceptable to our customers, to fit our methods of production to the various uses for which they are required, to attain efficiency in all the ways in which it can be cultivated, is as little work for one organisation as it is for one man. And no surer way could be found of hastening and deepening the disaster to engineering of any such concentration than to entrust it to the State, and make it the shuttlecock of every doctrinaire, amateur, and professional politician who saw in it the means of satisfying his theories or assisting party intrigues.

SEWAGE AERATION AND ACTIVATED SLUDGE.

WITHIN the last five years, and technically within half that period, the aëration treatment of sewage has entered upon a new and vigorous phase, and "activated-sludge" plants have risen, notably in the United States, some under severe conditions which must soon reveal the possibilities as well as the limitations of the new processes. Aëration of sewage has been advocated for half a century. When exposed to air currents for a sufficient time sewage breaks down and becomes oxidised, with the formation of a "humus" deposit and the final production of nitrites and nitrates from the ammonia and organic matter in the sewage. In itself aëration has proved too slow for practical purposes. During the same period, however, the prominent importance of bacteriological action in the tanks and in the filters has become more widely understood, and many engineers and chemists have tried, in laboratory and plant, to nurse the aërobic and anaërobic bacteria in order to obtain an inoffensive, stable effluent that may be discharged into a watercourse, and an inoffensive sludge that might be utilised as a fertiliser. Sewage farms have had their day, and still have their day when people do not insist upon settling near the ground, which was selected because the neighbourhood had previously not tempted settlers. The septic tank has not come up to expectations, and corporations have become very dubious about new sewage processes. It is a common experience to find that when things have been running for some time additional tanks or filters have to be provided, or the plant requires thorough overhauling or duplicating. As regards the new aëration processes, the development has been cautious in this country. The war has, moreover, interrupted promising investigations, and it will not be the first time that the country has profited from the more daring enterprise in the United States, where the first foundations for the processes were laid. That was done chiefly in the experimental station of the Water and Sewage Laboratories of the Massachusetts State Department of Health at Lawrence, probably the best-equipped station of its kind, of which Mr. H. W. Clark* is director; and over here by Dr. Gilbert Fowler, who visited Lawrence in 1912, in conjunction with Messrs. E. Ardern, M.Sc., and W. T. Lockett, M.Sc.,† at the Davyhulme Corporation Sewage Works, Manchester, and later at the Withington Sewage Works; by Mr. Duckworth and Mr. S. E. Melling, at Salford, by Mr. Craink, at Worcester, and by others. We will first outline the general features of the problems and then notice some installations.

Early in 1912 it was observed in Lawrence that sewage can be completely nitrated by prolonged aëration; in the first instance this took weeks. When the clear oxidised liquid was decanted off, and the deposited sludge was brought into contact with new sludge, a peculiar kind of "activated" sludge was obtained. This sludge is quite inoffensive, flocculent, and of dark brown colour; it contains not less than 95 per cent., mostly about 98 per cent., of water, is hence of low density, but yet can be drained, and turns into a stiff jelly. Ardern and Lockett found at least 30,000,000 organisms in 1 cub. cm. of this sludge, which was organic to 65 per cent.; 35 per cent. was mineral, 2.5 per cent. being phosphate (counted as P_2O_5), and the nitrogen percentage (14.6 of N) was extraordinarily high. There may be an actual accumulation of nitrifying organisms in the sludge during the destruction of the colloidal matter in the sewage, as Dr. F. R. O'Shaughnessy† believes; large numbers of such organisms were found, but the question is not settled. Carbon tetrachloride extracted 5.8 per cent. of the sludge, probably fatty substances; those would not be desirable in a fertiliser. The conclusions drawn from these experiments, which Ardern and Lockett made in bottles of about 4 litres capacity, provided with porous tiles through which the air was forced, were the following: the presence of activated sludge enormously increases the purification by simple aëration, and intensifies the oxidation, especially at ordinary temperatures (not below 10 deg. C. and not above 24 deg. C.). The aëration period of 6 hours (in 1914) was subsequently reduced, and it was found that the amount of air which would be required for the adequate mixing and circulating of the sewage was probably sufficient for aëration; but 12 cub. ft. of air per hour for 1½ hours were inferior to 6 cub. ft. for 3 hours. In practice an excess of air will, of course, be required, and that air might be introduced by mechanical means or by direct injection; only the latter will answer, however, as the air has to be "diffused," *i.e.*, as finely distributed as possible, so as to ensure intimate contact with the sewage. The sewage flow may be continuous, or on the "fill-and-draw" system. There seems to be some advantage in intermittent aëration, but the advantage is not pronounced. The activated sludge should always remain in contact with raw sewage lest fermentation set up; a few hours' re-aëration will, however, restore the activity. The proportion of activated to raw sewage should be 1 : 5, or higher, 2 : 5. The effluent does not as a rule contain much free ammonia nor nitrates—the formation of which would require too long aëration—the nitrogen going into the sludge. The effluent of Ardern was also fairly free from intestinal organisms, such as *bacillus coli* and *enteritidis*, originally in the sewage.

The experiments by Duckworth and Melling‡ were on a much larger scale, as they were made, in 1914 and 1915 (summer and winter), in two sections of a tank, each 90 ft. by 9 ft. and 4½ ft. deep, each holding 12,000 gallons. A 12-in. pipe carried air to the bottom of the tank, where smaller pipes, of 9 in., 6 in., and finally 4 in., distributed the air and discharged it through brass nozzles of ½ in. diameter.

In general the operation consisted of filling accompanied with blowing (1 hour), blowing (3 or 4 hours), lying quiescent (2 hours), running-off (1 hour). This was on the fill-and-draw method; continuous-flow experiments were also conducted, and in that case the return of the activated sludge to the aërating tank becomes important. These very interesting experiments—with 80,000 gallons daily of a very bad sewage—were interrupted by the war; there had been trouble because the air pipes became stopped up and had to be cleaned with steel pointers.

We have already mentioned the work done at Lawrence, at which station constant experiments with many sewage processes are always in hand. Activation has been practised there since 1912, and much experience gathered. But there has also been worked out at Lawrence another process, the algal growth process, not much studied over here. Fowler and Mumford tried an organism, which Mumford had isolated from ponds of colliery water, on sewage containing iron salts, and Clark gave comparative data of the two processes when the American Chemical Society discussed sewage purification at Urbana, Illinois, in April, 1916.* It was noticed in 1911 that the presence of certain algæ accelerated the purification of sewage in sealed bottles, and more still in aërated bottles; the sewage was treated for 24 hours and the bottles were then emptied, the growth and slime being returned. Then tanks were used, in which pieces of slate were placed one inch apart; these slates became coated with a brown-grey gelatinous growth. By 1915 sewage was treated in the experimental tanks of 100 gallons or 200 gallons capacity, provided with slates, and aërated for 5 or 10 hours; the longer aëration gave the more stable effluent and removed more of the colloidal and suspended matter. These tanks have been called "contact tanks" in England; Clark protests against this name, as the slate does not take up more than from 3 per cent. to 7 per cent. of the tank volume, and also against the statement that his process was merely preparatory to filtration. In the comparative experiments he found that 10 hours' algal aëration was better than 3 hours' activated sludge treatment and equally efficient as 8 hours of the latter, while requiring much less air, in spite of the longer hours. Sixty per cent. and more of the organic matter was removed, and the effluent and sludge were mostly satisfactory and valuable in both cases. The sewage temperature ranged from 40 deg. to 50 deg. F., the lower temperature seemed more favourable. On the whole the activated method seemed the more practical; but Clark added that really large scale experiments were needed and the processes might not answer for all sewages.

The city of New York started aëration experiments at their Brooklyn sewage disposal plant under Professor Phelps in 1910, and in 1913 a 16,000-gallon cylindrical tank, 12 ft. diameter, 25¾ ft. high, was built. It is provided with a grid, resting on broken stones and supporting more of these stones, the grid being made up by air pipes, crossing or arranged in rings, from which the air rises, to be distributed by deflectors which resemble wheels. Here, also, continuous-flow and fill-and-draw methods were tried; the former proved risky, as the sludge deteriorated. Aëration was applied for 5 hours with 7 volumes of air for 1 volume of sewage. Black and Phelps, we should mention, had also experimented with algæ in New York Harbour.

At Baltimore matters are still in an experimental stage on a smaller scale. Special attention has been paid there to the porous materials, which were first tested in disc specimens, 3 in. by 1 in., clamped to a recessed flange; later, larger samples were used. Unglazed tiles and cement broke when the air was forced through; "filtros" tiles were easily permeable, but gave too large bubbles; carborundum and alundum answered, though they became easily clogged with oil; alundum was discarded as too expensive, and carborundum may be regarded as unsuitable for the same reason. At Urbana, Illinois, E. Barton and F. Mohlmann found that

* *Engineering Record*, March, 1915, and previous years; *Journal of Industrial and Engineering Chemistry*, July, 1916.

† Journ. Society of Chemical Industry, 1914, pages 523–529 and 1122–1124; 1915, page 937; 1916, page 153; 1917, pages 65–68 and 264–269.

‡ *The Surveyor*, December, 1914 and 1915; Journ. Society of Chemical Industry, 1914, pages 1124–1130.

* *Journal of Industrial and Engineering Chemistry*, 1916, pages 642–654.

when a tank, 10 ft. by 10 ft. by 8½ ft. deep, was provided with only a central trough made up of filtros plates with sloping sides, or had only one filtros plate in the pyramidal bottom, instead of being all flat and covered with filtros plates, the aëration was insufficient.

The further experience gained in large American installations brings out considerable discrepancies, though many results are decidedly encouraging. One of the most severe tests of the activated-sludge method has been the treatment of the sewage from the packing houses of Messrs. Armour, Chicago, described by P. Rudnick and G. L. Noble. The establishment comprises abattoirs, a lard refinery, oleomargarine works, meat canning, curing, and sausage departments; the wastes are mixed with the sewage of 10,000 people, and the deep-well water used contains more than 2,000 parts of solids per million, so that the total solids and suspended matter in the sewage are quite exceptionally high; some of the refuse is quite cold, some hot. The sewage is pumped into a weir box, and passes into the aërating tank, 10 ft. by 20 ft., 10 ft. deep, in which it is aërated for 10 hours; there are baffles and ¾-in. air pipes, perforated with holes of $\frac{1}{16}$ in., 2 in. apart and staggered, placed at 4-ft. intervals at right angles to the line of flow. Activated and raw sewage (30 : 100) are admitted simultaneously; the liquid is then allowed to settle in a special chamber for 1 hour, and effluent and sludge are siphoned off. The total air supply is at the rate of 3 cub. ft. per gallon. The dehydration of the sludge, which contains 99.5 per cent. of water, could not be satisfactorily effected in filter presses, whose cloth rapidly became clogged, nor in bowl-centrifugals; when the moisture is reduced to 50 per cent., however, the drying is easy. As regards the tank depth, experiments with 18 ft. and with 36 ft. pipes were equally successful, so that deep tanks will be tried. Bacteriologically a sewage temperature of 20 deg. C. appeared preferable to 35 deg. C.; above 75 deg. F. (24 deg. C.) the sludge turned inactive. With all these difficulties the treatment is considered as more satisfactory than any other tried.

The tannery waste and sewage of Messrs. Winslow and Smith, Norwood, Mass., somewhat resembles the Armour works sewage. In this case there are 30,000 gallons daily of wool-scouring liquors (imperfectly degreased by acid) and 500,000 gallons of tannery waste, very turbid and malodorous. Trickling filters had previously been used with some success, except that the sprays disseminated foul odours and the fly pest was great. The activated-sludge process is used in a 1,000-gallon tank, 6 ft. by 3 ft., 8 ft. deep, with a false bottom of filtros plates, 6 in. above the bottom. The joints between the filtros plates were first made with a roofing compound, which melted or softened at 70 deg. and 80 deg. F., and was replaced by pitch and cement mortar. Even then trouble occurred when the refuse was heated by steam, and the tank became foul, but it was cured by vigorous aëration. With 0.25 cub. ft. of air per hour per gallon the effluent was not always stable, even with 20 hours' aëration; yet the treatment was promising. The soapy liquid frothed a good deal, especially while the degreasing appliances were being improved, and for this reason the air supply had to be kept low. A similar treatment of the paper-mill waste of the firm was unsuccessful.

It will have been noticed that the tannery waste required high temperatures. At the Milwaukee Sewage Testing Station the temperature difficulties are much less marked, although the fluctuations are very great. The plant lies on Lake Michigan, in a very exposed position, and the temperature dropped to — 15 deg. F. during the winter 1915–16; yet the sewage temperature only fluctuated between 67 deg. and 50 deg. F., except after heavy snowfalls, when it went down to 40 deg. and 34 deg. F.; during these cold days the period of stability of the effluent from the activated tanks decreased from 5 to 3 days. One million gallons of sewage yielded 3,000 gallons to 4,000 gallons of sludge which contained 98 per cent. of water. The sludge would not filter, and the addition of lime to the sludge to give it more body made matters worse; centrifugals also failed, but some special presses of the Henry Worthington Company overcame the trouble. It is estimated that it would cost 5 or 6 dols. per ton to prepare and transport a sludge which would sell at 10 and 12 dols., and tanks for dealing with 2,000,000 gallons of sewage are being planned.

At Brockton, Mass. (62,000 inhabitants), the municipal sewage works have, since 1894, used 37 acres of filter beds, to which a half-acre of trickling filter beds was added four years ago; only one-third of the daily sewage (2,100,000 gallons) was passed through this trickling filter and then through sand beds. The trickling filter was disappointing, and, after experimenting, a large activated-sludge plant was put down; the effluent is filtered. Complete nitrification of the sewage by prolonged aëration, which is not as a rule attempted, and probably not desirable, seems to be impossible at Brockton with the refuse from the spent dyes of the shoe factories.

Although these various experiences can hardly be considered satisfactory on the whole, the activated-sludge process is going ahead. The *Engineering News* of February 8, 1917, describes two new installations. The town of San Marco, Texas, has put down plant for 150,000 gallons of domestic sewage daily, which is stated to have worked satisfactorily since September, 1916. The aëration tank is 16 ft. wide, 40 ft. long, 8½ ft. deep above the filtros plates (52 in all), and divided into four channels; from the outlet the sewage passes into a settling tank, 25 ft. deep. The air is delivered by a blower under 5 lb. pressure at the rate of 250 cub. ft. per minute. Some of the filtros plates became choked and acted erratically; each of these was replaced by a small air pipe. The whole plant was laid down at a cost of 3,500 dols.

The new plant opened last April, at Houston, also in Texas, is a much more ambitious scheme. Houston (140,000 inhabitants) is not a new town, since it dates from the time of the Texas rebellion against Mexico in 1836. The works, for 19,000,000 gallons of sewage daily, had to be divided into two plants—one of 4 units, one of 2 units—situated on opposite sides of the town; each unit can deal with the sewage of 37,000 people at an average flow of 2,910 gallons per minute. Each unit consists of a rectangular, continuous-flow aëration tank, a battery of 10 vertical-flow settling tanks, and one sludge re-aëration tank; air is supplied at 5¼ lb. per square inch. An aëration tank of 340,000 gallons volume, 280 ft. by 18 ft., is 9¾ ft. deep above the filtros plates, which are 12 in. by 12 in. by 1½ in., set in frames in rows 5 ft. apart across the tank; there are 112 frames (each holding six plates), and the ratio of aërator to tank surface is 1 : 7½; 0.26 cub. ft. of air per minute per tank surface is to be supplied. The aëration is to last 1½ to 2 hours. The channel leading to the settling tanks has a length of 104 ft., and is itself lined with aërators; the 10 settling tanks are arranged along the channel, being 10 ft. by 19 ft., 22 ft. deep, with conical bottoms; a vertical 8-in. pipe goes down to the bottom. A blanket of sludge somewhere beneath the surface is designed to catch fine suspended particles; this blanket is a new suggestion, about the advisability of which there is some doubt, because the flow will have to be kept gentle not to disturb the sludge. From these tanks the sludge passes through a channel into the re-aëration tank, 9 ft. by 280 ft., which resembles the aëration tanks. The material used is reinforced concrete, with sloped walls and trowel finishing to avoid all accumulation of sewage; dead spaces and corners are all filled in. The pipes are wrought iron, from 12 in. to 4 in., and down to 2 in. in the aërator frames; all screws and bolts are made of bronze. The air-meters are Pitot tubes with differential gauges. The total estimated cost amounts to 367,000 dols.

When the activated-sludge problem was discussed at Manchester in September, 1915, in connection with the papers by Ardern and Lockett, Dr. Fowler was so convinced of the high manurial value of the activated sludge that he referred to the sewage purification as a mere incident. Mr. Halliwell rather put a damper on that optimism. The accumulation of sludge constitutes a nuisance, and the sludge has to be got rid of; if we can make a fertiliser or something else out of the sludge, all the better. Dr. S. Rideal dealt recently with the recovery of fats and nitrogen compounds from sewage.* But we would not rely too strongly on such hopes, though we do not forget that agriculture is, at last, receiving in this country the serious attention it deserves. We first have to produce a saleable sludge, and in that respect the accounts we have noticed are sadly defective. To dehydrate and dry a sludge, which is practically slimy water, without fouling the presses or machinery, is a serious problem, about the solution of which very little is said so far. We have yet much to learn about the maintenance and repairs of the aëration tanks, the troubles caused by grit, the corrosion and stopping-up of air pipes, the clogging of aëration plates and their removal and renewal while the tanks are kept in operation. Many of these difficulties are fortunately not novel to the sanitary engineer. Duplication of part of the plant may prove indispensable, and the aëration will be a costly item. On the other hand, chemicals are not required, at least not under normal conditions. Even with sewages strongly varying in quality and quantity good aëration seems to be able to do much. In Emscher tanks, which make use of iron salts, trouble has sometimes arisen when the sewage was rich in carbohydrates and poor in nitrogenous matter, from the formation of a layer of acid, offensive sludge floating on the liquid, which would not drain well.* Brisk agitation and aëration of the mixture of sludge and sewage (1 : 2), if necessary with the addition of a little lime, is said to cure this trouble. By the time the country will be in a position to attack big sewage schemes the activated-sludge problem will be clearer.

* *Chemical Trade Journal*, 1916, page 571.

THE STRUCTURE OF MATTER.

SINCE Professor Bragg lectured before the Institute of Metals on X-rays and crystal structure,† a year ago, further striking developments have become known of X-ray studies, not only of crystals, but also of amorphous substances, liquid crystals, liquids and gases. The dimensions of the hydrogen molecule and of the benzene ring have been deduced, and it seems possible to determine the number and grouping of the electrons in the atom. In his original experiments of 1912 M. von Laue was guided by the consideration that the grouping of the atoms in crystals should act like a natural grating, sufficiently fine to produce a diffraction of Röntgen rays, not realisable so far with artificial gratings. He passed a beam of rays normally through a crystal on to a photographic plate; the resulting diagram showed dark spots arranged in circles passing through the central spot, and the intensities and positions of the spots allowed of drawing conclusions as to the grouping of the atoms in the crystal. Modifying the method, Professor Bragg and his son made a beam of homogeneous X-rays fall obliquely on a crystal; the successive parallel planes, in which the atoms are supposed to be arranged in the crystal, reflected the rays at certain angles, and from the interferences and ionisations produced either the spacings of the planes or the wave-length of the rays were deduced. Both the methods are used, and give, on the whole, concordant results; the Bragg method seems the more convenient and less difficult of interpretation; but it appears restricted to the examination of crystals.

Working with Laue, Friedrich and Knipping also obtained certain results with fine powders of crystals. Taking up this line of research, P. Debye, of Amsterdam, and P. Scherrer argued that the regularity of the grouping of the electrons should remain recognisable even in irregular masses of powders. Homgeneous X-ray illumination would excite a secondary radiation, which would not be uniformly radiated into space, but show maxima and minima lying on cones, the axes of which would coincide with the direction of the primary ray. When starting with crystals the effects of this grouping of the electrons would be complicated by the interference due to the orderly arrangement of the atoms. Experimenting with amorphous substances and powdered crystals, Debye and Scherrer pressed the material into cylindrical rods, 2 mm. in diameter, 10 mm. long, and placed the rod in the middle of a cylindrical camera; the X-ray beam fell through a bore of

* *Chemiker Zeitung*, 1916, page 347.

† See ENGINEERING, June 2, 1916, page 518.

2.5 mm. in a block of lead on the cylinder and was reflected on to curved films. To secure cohesion the cylinder of powder was coated with collodion. The photographs obtained look like spectra, the lines of which are straight in the central portion, but become more and more curved on both sides; they may also be likened to the pattern produced when polarised light traverses a biaxial crystal. In some lines black specks can be distinguished; this was noticed in the case of amorphous silicon, and is ascribed to the presence in the powder of small crystals which happened to lie properly orientated to reflect the primary rays from the copper anti-cathode. From the measurements the length of the elementary cube was calculated: silicon, 5.46; graphite, 4.69; lithium fluoride, 4.14, all multiplied by 10^{-8} cm.; the shortest distance apart of two silicon atoms was estimated at 2.33×10^{-8} cm.

Debye and Scherrer conducted similar experiments on gases and liquids at Munich and Göttingen; particulars of this method are not available. Accepting Bohr's hydrogen molecule, however, as consisting of two atoms at the ends of a polar axis and two electrons moving diametrically to one another on a circle equatorial to the axis, they calculated that the distance between the two atoms is 0.604 and the diameter of the equatorial circle 1.05×10^{-8} cm., and that the electrons describe 7×10^{15} revolutions per second. The benzene molecule C_6H_6 is supposed to consist of six groups of CH at the corners of a hexagon (the benzene ring); the diameter of this ring is estimated at 12.4×10^{-8} cm., a side at 6.2×10^{-8}, and its thickness at the most at 1.9×10^{-8} cm. From the molecular refractivity and dispersion, on the other hand, L. Silberstein, of Rome (*Philosoph. Magazine*, February, 1917), calculates the distances between the atoms in the molecules of hydrogen, oxygen and nitrogen at 1.067, 1.265 and 1.493×10^{-8} cm., and that the number of dispersive electrons is in each case that of the normal valency. The dimensions agree with those deduced from the kinetic theory of gases.

Building on these and on similar researches, and upon J. Stark's dynamics of the atom, F. Rinne (Leipzig), in his leptonology (or study of the fine structure of matter), shows that the different forms of matter, gas, liquid, liquid crystals, crystals, form a continuous series. Not a very novel conclusion, it may be objected; but it is based upon reasoning which only the recent researches justify and upon somewhat successful attempts (M. Born) to deduce the properties of solids from their atomic grouping. The crystalline state, it is suggested, is characterised by a three-dimensional, periodic and straight-line orientation of equal particles, combined with a capability of indefinite extension of the periodic structure. This latter capability is ascribed to residual valencies in the surface layers (Huber and Panetti), and it is owing to them that certain isotopes fall out together (Fajans and Richter). In amorphous solids, which are least understood, though distinguishable from crystalline matter by X-rays, this extension capability is missing. It persists to a certain extent, however, in the liquid crystals of O. Lehmann, which arrange themselves in lines parallel to the principal molecular axis under the influence of internal forces—external forces of the magnetic field, *e.g.*, do the same in the case of nitrobenzene, for instance—while the particles retain the mobility of liquids to some degree. The ring structure of true liquids like benzene, and still more the tetragonal structure of tetramethylene leads over from amorphous liquids to liquid crystals. Even amorphous gases like hydrogen are not devoid of orderly structure; though not of a three-dimensional periodicity, they conform to geometrical rules.

THE COALFIELDS AND COAL INDUSTRY OF JAPAN.

JAPAN and its colonies, as regards coalfields and the coal industry, may be divided into three sections:—(1) Japan proper, consisting of a group of four large islands and innumerable small ones; (2) the southern half of the island of Saghalien, known to the Japanese as Karafuto, taken from the Russians during the Russian-Japanese war, and annexed after the Treaty of Portsmouth early in 1906; (3) and the island of Formosa (Japanese, Taiwan), taken from China during the Japanese-Chinese war. Coal also occurs in Korea (Japanese, Chosen), but details are not at present available. Considerable information concerning the Japanese coalfields has been gathered, as a geological survey was commenced by a well-organised staff as far back as 1878, and a large number of maps have been published to a scale of 1/200,000 (approximately an inch to 3 miles). As regards mining, European methods have been introduced under Government supervision, large numbers of mining experts having been engaged from both Europe and the United States. Now highly trained native engineers are employed in managing and developing the coal industry. The Japanese authorities very properly attach great value to this industry, as coal is the most important of the minerals occurring in Japan. Of the Japanese coal consumption about 24 per cent. is required for steamships, 16 per cent. for railways, approximately 50 per cent. for factories and works, and 10 per cent. for salt production.

The export of coal to the outbreak of the present war has been of the following values:—

	£
1901	1,791,000
1903	1,967,000
1905	1,457,000
1907	1,945,000
1909	1,766,000
1910	1,665,000
1911	1,837,000
1912	2,071,000
1913	2,413,000
1914	2,442,000

These exports go to China, Hong-Kong, the Straits Settlements, the Philippine Islands, the Dutch Indies, in the order named as regards quantity, and in smaller amounts to East India, Siberia and the Pacific ports of the United States. Coal is also imported to the value given below:—

	£
1911	158,000
1912	246,000
1913	412,000
1914	684,000

The coal deposits occur in five fields, of which three, Nagasaki, Saga and Fukuoka are situated in the most southerly of the four large islands mentioned above, the Hokkaido coalfield in the most northerly island, and the Fukushima coalfield about the centre of the largest island, not far from Tokyo. These Japanese coal deposits differ from those in this country in one remarkable point: whilst ours were accumulated during the Carboniferous period, and belong to the Primary geological age, those in Japan occur among the Tertiary rocks. Anthracite, brown coal and lignite are found. The coalfields of Japan proper may extend over, in round figures, 800 square miles, of which about one-fifth is now being developed. The lignite occurs only in limited areas and in relatively small quantities. The most important of the coalfields is the Fukuoka, known also as the Chikuho, not far from the harbour of Wakamatsu; it extends over a length of some 25 miles and varies in width from 8 miles to 10 miles. The coal seams may be divided into two groups, an upper and a lower; the former has seven beds of coal and the latter two, one 8 ft. in thickness, increasing locally to as much as 20 ft., and the other a thickness of 6 ft.; they contain the best coal.

The Japanese have two systems of working their coal mines—by inclines and by shafts; the great development of the industry has resulted in the latter to a considerable extent superseding inclines. Some of the Japanese coal workings, like those near Whitehaven (Cumberland), extend under the sea, suggesting a different land and sea distribution, from that now existing, during former geological ages. As far back as 1910 electrical power was introduced for the working of colliery plant in Japan. A central power plant was installed to supply current both to surface and underground machinery; it was also used for lighting requirements. The distribution system employed consisted of bare overhead wires; each feeder supplied current from the power station to a sub-station convenient to the pit mouth. The supply to the motors and the current used for lighting the pit was distributed from centres underground.

Mining and prospecting title-deeds in Japan are of three kinds—those limited to prospecting, those for mines actually being worked, and those for mines either abandoned or in abeyance. Up to the present 1,300 to 1,400 title-deeds have been issued for coal deposit prospecting, with an aggregate area of about 74,000 acres. There are now approximately 560 title-deeds in force for mines at present in operation, with a total area of about 23,000 acres, and over 1,200 title-deeds for mines either abandoned or not being worked, with an area in round figures of 27,000 acres. During the last decade the number of miners has about doubled, and is now about 175,000 men; whilst the annual output may be estimated to reach well over 20,000,000 metric tons. The most important Japanese coal mine now produces over 2,000,000 tons annually.

Very little was known of the mineral resources of Saghalien until it was annexed after the war, when the Japanese Government, with great public spirit, organised a geological and mineralogical survey of the southern half of the island. For several years the surveyors devoted their main attention to coal, and ascertained that it occurs practically over the whole area of Japanese Saghalien, which has been described as one huge coalfield, with almost inexhaustible supply. The coal has been described as being of good quality in general, comparable with the best occurring in Japan proper. Unfortunately the severe climate and limited population make coal-mining difficult. To quote an authority: "Whilst it is comparatively warm during the summer, it is exceedingly cold in the winter; the average annual temperature being very low, ranging from only 29 deg. to 38 deg. F. The temperature is highest in the south-west, growing generally colder towards the north-east. Throughout the whole province the temperature may fall to 60 deg., or more, below zero Fahrenheit during the winter, which would be an effectual bar to coal-mining."

The coal deposits may be divided into three fields—the northern, the middle and the southern, of which the central is the most extensive, no less than 60 miles in length, with an average width of 1½ miles. It is situated in that portion of the island traversed by a narrow-gauge railway, where the land takes a great sweep to the south-east. The strata are very regular, very slightly faulted, and the seams are thick, rendering coal getting comparatively easy. The river valleys provide interesting sections and exposures, giving useful keys to the geological structure and history of that portion of the island. The northern coalfield extends along the east coast to the international boundary, and no doubt continues into Russian territory. The southern coalfield is situated in the central portion of the Notoro peninsula; it differs from the others in so far that the strata have been very much disturbed, the inclination of the seam being frequently at a high angle. It is conceivable that these coalfields, in spite of arctic weather conditions, may have a future; those in Spitzbergen, with possibly lower temperatures, are to be opened out. The enormous populations of eastern Asia may provide a market which may tempt capital and enterprise.

The island of Formosa differs from Japan proper in being a semi-tropical country; it has an area of about 13,000 square miles, nearly equal to that of Denmark, and contains considerable coal deposits, but until a geological survey has been made and geological maps are available no very precise information and details are available. Most of the known mineral deposits occur in the northern half of the island. The annual output of coal is now approximately 350,000 tons, of which possibly one-fourth is exported.

TURRET FOR TURNING THE COPPER BANDS ON SHELLS.—With reference to the description in our previous issue (page 614) of the copper band turning turret made by Mavor and Coulson, Limited, Glasgow, we now learn that since the details were sent to us the dexterity of the women workers has so increased that 270 4.5-in. bands have been turned in 10¼ working hours. The best time for turning an individual band from start to finish is 32 seconds; considering the form of the band of the Mark VII shell, this is a remarkable performance.

NOTES.

LARGE STEAM-TURBINE PLANTS.

IN a paper recently read before the National Association of Cotton Manufacturers, Mr. J. A. Stevens, of Lowell, stated that a turbo-alternator having a maximum output of 70,000 kw., or 100,000 h.p., was now in course of construction, and that still larger units were contemplated. The largest reciprocating engine yet built belongs, he stated, to the Lukens Steel Company, and is capable of developing 25,000 h.p. Mr. Stevens further stated that in general the reciprocator in small sizes is more economical than the turbine, but that the latter has the advantage when the rated output exceeds 200 kw., and he believes that by the use of reduction gearing the limit of output at which the average reciprocator is superior to the turbine may be reduced below 100 kw. At outputs of 1,000 kw. the turbine is, he says, equal in economy to the largest and best reciprocator ever built. He states that the thermal efficiency of the turbine has now been raised to 26.5 per cent., this proportion of the total heat of the steam being recoverable as useful work. Large turbines of 30,000 kw. or so cost 8 dols. to 9 dols. per rated kilowatt, as against 20 dols. to 25 dols. per kilowatt for a 500-kw. unit. With these large units he states that the coal consumption per kilowatt-hour is about 1 lb. To feed these very large units the author has, in conjunction with Mr. A. D. Pratt, of the Babcock and Wilcox Company, designed a boiler capable of furnishing steam for a 30,000-kw. turbine. This boiler has a grate area of 936 sq. ft. to 1,108 sq. ft., 57,600 sq. ft. of water-heating surface, and 14,352 sq. ft. of superheating surface, with 36,800 sq. ft. in the economiser. It contains 10¼ miles of 4-in. tubes in the water-heating surface alone. In normal operation it converts into steam 62,000 gallons (U.S.) of feed per hour, the working pressure being 350 lb. per square inch and the superheat 250 deg. F. The ground area occupied is only 90 ft. 6 in. by 84 ft. 4 in., inclusive of bunkers and firing aisles. It is interesting to compare these figures with similar estimates given in a paper read before the Municipal Electrical Association by Mr. J. A. Robertson, the Salford borough electrical engineer. Mr. Stevens states in his paper that the Westinghouse Company are guaranteeing a thermal efficiency of 26.5 per cent. for a 50,000-kw. turbine now building, the steam supplied at 300 lb. pressure per square inch with a superheat of 200 deg. F. The vacuum specified is equivalent to a back pressure of 1½ in. of mercury. Mr. Robertson, in his paper, quoted an offer made by a British firm for a turbine taking steam at 350 lb. pressure and superheated about 270 deg. F. The thermal efficiency of turbine generator and auxiliaries was guaranteed to be not less than 26.39 per cent. In this case the vacuum specified was equivalent to a back pressure of 1 in. of mercury. Probably the plant to which Mr. Robertson's figures referred was much smaller than the gigantic machine Mr. Stevens had in view, and the latter does not in his estimate debit the turbine with the power taken by the auxiliaries. The figure he gives corresponds to an efficiency ratio of 78.8 per cent. Some turbine engineers expect that by the adoption of high pressures and superheats they will be able to supply 1 h.p. at the turbine shaft for each 8,000 British thermal units per hour entering the turbine. Little, however, has as yet been accomplished in this connection, and those firms who have experimented with exceptional pressures and superheats have so far published little as to the actual results, though these are understood to be highly favourable.

ADVANCE IN COKING PRACTICE.

Discoursing before the Society of Chemical Industry at Leeds, last April, on "Some Future Lines of Advance in Coking Practice," Mr. G. E. Foxwell drew attention to several points in which England might profitably follow American lines. In this country, Mr. Foxwell said, probably no coke ovens carbonised in less than 24 hours, whilst the 560 Koppers ovens of Gary, each of a capacity of 12¾ tons per charge, burnt off their charge in 16¼ hours. The coal over there contained 15 per cent. of volatile matter, and yielded 12,200 cub. ft. of gas, 18 lb. of ammonium sulphate and 4 gallons of tar per ton; such a coal in England would give 10,000 cub. ft. of gas, 5 gallons to 6 gallons of tar and 20 lb. of ammonium sulphate in 26 hours; very few English coke ovens took charges of more than 10 tons, moreover, mostly only 5 tons. The secret of the quick-burning American oven was supposed to lie in the high silica percentage—95, against 80 over here—of the bricks, and the bricks could certainly be improved in various respects, though that would require much research. Mr. Foxwell did not refer to low-temperature carbonising, for which he has no preference at all, except in reply to remarks by Mr. W. McD. Mackey. As regards scientific coal-blending, he stated that English coking plants were usually—though not by any means always—built at the colliery; the slack coal from all the pits was sent to the ovens, and as long as a good coke was produced, no further attention was paid to that matter; but certain coals did not alone give a saleable coke, and were not sent to the ovens therefore, although they might indeed yield more by-products than better-coking coal. In America the plant was worked for some days on certain mixtures, and the proportions were changed to obtain the best results. Coke quenching should not be left to the discretion of the quencher, who, when inexperienced, passed too wet or too hot a coke into the wagons, and could not be expected in any case to be as good a judge in night time as in daylight; the hot coke should fall into a basket and be conveyed to a trough, to be immersed in water for a definite time. All the coke breeze, which probably amounted to 595,000 tons in 1915 (5 per cent. of the coke produced in this country), should be briquetted or otherwise utilised; at present much breeze found its way to the refuse heap. The recovery of by-products should begin before coking. The iron pyrites might, for instance, be recovered from the washery in two ways. The washery refuse could be treated first in a special producer of the Mond type and subsequently by Feld's polythionate process, or the coke oven gas, after extraction of its products, might be passed over the carbonaceous shale which, heated by the gas, would yield sulphur, sulphuretted hydrogen and iron (for the blast furnaces). The sulphur content in the coal was often sufficient to provide sulphuric acid for binding the ammonia. To start lead chambers for oxidising this sulphur to acid was only advisable for large plants, however, and the Burkheiser and Feld processes, which avoided the necessity of manufacturing sulphuric acid, still offered many difficulties. Further, the whole system of recovering all the ammonia as sulphate seemed irrational. There was often enough chlorine in the coal to justify the direct recovery of the ammonium chloride by spraying the gas at 120 deg. C. with water at 70 deg., instead of decomposing this salt by milk of lime and binding the ammonia by sulphuric acid; this chloride recovery was in use at a few works. The further treatment of the gas was one of the most promising fields for research. Naphthalene was a neglected, and sometimes a troublesome product. It could be removed and recovered by sudden cooling of the hot gas or by the aid of creosote oil, which absorbed the naphthalene and benzol; on subsequent distillation of the benzol the naphthalene would solidify, but so far as the naphthalene was concerned this otherwise satisfactory process was very inefficient. The washing of the crude benzol with sulphuric acid and water was also open to improvement, especially with regard to the recovery of phenol, pyridine and thiophene. The present system of working for 65 per cent. benzol was not the best, either, with respect to toluene.

MALLEABLE CAST-IRON.—Experiments by F. Wüst and E. Leuenberger (*Ferrum*, 1916, pages 161 to 172) show once more that the melting of iron in either a cupola or in an oil-fired furnace has a decided influence on the sulphur content and consequently upon the properties of the iron, because the oil fuel as a rule does not contaminate the metal with sulphur. Malleable iron from an oil furnace, they found, is superior to cupola iron in tensile strength, elongation and contraction of area. When the time of heating is prolonged the tensile strength, and also hardness, fall off at an increasing rate, while the elongation and contraction become more pronounced; toughness and resistance to shock also increase with the time of heating; heating also lowers the density of the iron, but the time element is of no importance there.

LITERATURE.

The Range of Electric Searchlight Projectors. By JEAN REY, Ingénieur civil des Mines, Lauréat de l'Institute. Translated by J. H. JOHNSON, M.Inst.C.E., Assoc.A.I.E.E. London: Constable and Co., Limited. [Price 12*s.* 6*d.* net.]

AT a time when the national mind is exercised concerning the adequacy of its defences against attack, attention is of necessity directed to the employment of the electric searchlight and its capacity to detect the approach of a stealthy assault by sea or air. The demand for increased information is inevitable, and this book makes its appearance at an opportune moment; its welcome will be enhanced by the fact that the problems treated have hitherto received little attention. On that ground we could have wished that fuller details had been supplied of the structure of these machines, of the recent improvements that have been introduced owing to war demands, and of the methods of photometry on which the results have been based. Enlightenment on some of these points may have been indiscreet, and information on others appears to have been supplied by the author to the International Society of Electricians in Paris in 1902 which it has not been found convenient to repeat in this treatise. We must not forget, however, that the author's object is simply to discuss the range of projection of the light emitted, or to determine what amount of illumination will be distributed over a distant object under given conditions of transmission and absorption.

The only illuminant now used in searchlight apparatus is an arc light between carbon points, placed in or near the focus of a reflecting mirror. Practically it is found advantageous to place the carbons parallel with the axis of the mirror, the negative having a smaller diameter, being placed nearer the surface. Since the source of light is coincident with, and confined to, the incandescent crater formed in the positive carbon, it is evident that this arrangement entails the loss of a considerable amount of light, however much the diameter of the negative carbon is reduced. In the earlier forms of apparatus, to avoid or minimise this obstruction, inclined carbons were adopted, and this seems to have been an obvious improvement, especially when the focal length of the mirror was comparatively large, but in practice this advantage was more than compensated by the increased difficulties in regulating the position of the carbons, requiring as it did a more expert staff. This is not the only direction in which theoretical advantages have had to yield to the necessities of practice. The deposition of silver on glass, which forms a most efficient reflecting surface, has had to give way to the employment of gilded metallic mirrors having a lower reflective power. In warfare the searchlight is subject to rough usage, and a glass mirror is liable to be broken or to suffer from shocks due to gunfire or accidental injury in transport. Certain it is that military men prefer the less fragile form of gilded mirror to all types of glass reflectors. The difference in reflective efficiency between the two forms is reduced by the necessity of silvering the mirror on the back, and the light having to pass through the glass a considerable percentage is scattered and absorbed at the surface and by the thickness. Fifteen per cent. of the incident light may be regarded as lost from these causes. Before dismissing the subject of mirrors reference should be made to the ingenious form adopted by Colonel Mangin. He proposed a class of reflector having a double spherical surface, formed of a concavo-convex lens silvered on its convex face, whose radius of curvature was larger than that of the concave surface. Such a mirror is thicker at the edges than in the centre, and with appropriate curves the spherical aberration can be made very small if the focal length does not fall below 70 per cent. of the diameter of the mirror. Mirrors of 1.5 m. diameter have been successfully constructed on this plan. If the focal length be reduced beyond this proportion in order to secure other advantages, as for example, a more extended illuminated field, the glass at the edge becomes so thick that the loss of light by absorption is very considerable, while the greater weight of the instrument makes it difficult to handle

and increases the risk of fracture. The Mangin has therefore been displaced on active service. The electrician, by improved technique, has made available such a powerful light that theoretical considerations become of less importance, but the optician will continue to regard with satisfaction a combination that, while giving a smaller diameter to the beam than does the parabolic mirror, ensures an illuminated surface greater in the ratio of the square of the respective focal lengths.

The carbons next claim attention. With continuous current that may reach from 200 to 250 amperes the carbons have to be of considerable size and call for care in the manufacture. The positive will need a diameter of about 35 mm. and the negative half that measurement. By adopting a special composition it is possible to keep the incandescent crater very concentrated, thus increasing the total useful luminous flux, and recourse is had to heavy coppering in order to keep the area small. But carbons of small diameter rapidly burn away, seriously reducing the available hours, besides requiring frequent attention and renewal. The determination of the intrinsic brilliancy of the combination will be accompanied by great difficulties and much uncertainty. The formation of the crater will not be regular, but unevenly hollowed, and not a negligible part of its surface will be hidden by indentations following no law in their formation. There will still remain three variables affecting the efficiency of the incident light that can be submitted to experimental investigation. These variables include the diameter of the crater, the electrical current and the part played by the negative carbon. With these must be combined the focal length of the mirror, which materially modifies the available brilliancy.

For the diameter of the crater the author gives the expression

$$\delta = 0.344 \sqrt{D\,I}$$

where δ is the diameter of the crater, D that of the positive carbon, and I the amperage. Presumably the distance between the carbons is not immaterial, as the shadow effects due to the lamp generally would vary with a change of distance. The regular burning of the lamp and the shape of the crater, that is, the depth of the hollow, would likewise be affected, but this point is not worked out either theoretically or experimentally. The size of the crater, which is considered to be fixed by the relation given above, is a matter of no small importance. On this factor depends the diameter of the beam or of the illuminated field, which must have considerable dimensions to facilitate the recognition of an object on which the light falls. If one could see only a section of a ship, for example, the identification would not be easy.

The variation of the illumination, depending upon current, voltage and the diameter of the carbons, involves many variables, and the problem is by no means simple of solution. To say that the total flux of an electric arc is in direct ratio to the product of the intensity in amperes and the electromotive force at the terminals of the arc in volts, carries us but a little way. The statement gives no indication of the effect of varying any one of the factors, and any result has to be modified by the chosen focal length of the mirror. To overcome some of the difficulty the author seeks a practical answer to the pertinent question, "What are the most advantageous diameters for the carbons and of the corresponding values of current and voltage?" It is shown that it is desirable to increase the current if the diameter of the carbons be kept constant. With a pair of carbons of respectively 28 mm. and 13 mm. diameter the most satisfactory current is 120 amperes, and if the carbons are increased to 31.5 mm. and 14 mm respectively the current should be increased to 150 amperes. Similarly, in tracing the effect of focal length or the ratio between the focal length and the diameter of the mirror, the inquiry shows that the illumination increases as the focal length is increased from one-third to three-fifths of the diameter, and it may be asked whether this increase would continue if the ratio were further increased. It appears that a focal length equal to 0.664 of the mirror diameter would correspond to a maximum illumination, but in modern searchlights the focal length is usually less than this. Practical considerations connected with the diameter of the beam again demand a modification of the theoretical rule.

The final object sought in the discussion must be to determine the amount of illumination that will be thrown upon an object at a definite distance. Before this can be known it is necessary to take into account the losses due to other parts of the instrument that obstruct light, as the protecting glass in front (usually with joints between the panes of glass) and the system of louvre shutters used to mask the beam in signalling. If all the sources of loss, whether due to absorption or shadow, but omitting all reference to atmosphere and causes external to the machine, are summed up, it will be found that the efficiency of the entire apparatus is reduced, in the case of a small searchlight to about one-half, and in a large to two-thirds of the initial light.

The external elements influencing the light depend on the varying transparency of the atmosphere, the distance of the object, its colour and contrast with the background. The distance of the observer from the searchlight and from the objective is also a factor. The author analyses the effect of each of these at very considerable length, estimating the absorption by the atmosphere over sea and over land, the effect of climate in different parts of Europe, and various physiological problems connected with the sensitiveness of the retina. This protracted inquiry indicates what average results may be expected with instruments of particular size, and may be of assistance in selecting a searchlight fitted to do specified work in a given locality. It decides the upper limit attainable, but it seems to us of little further use. Fogs or dust will reduce the penetrating power of the light from kilometres to metres, and render the most carefully constructed tables or diagrams useless. The diagrams are prepared with care and ingenuity, and would be useful if it were required to determine the distance of an object from the amount of illumination received, or the minimum of light necessary to reach an object of known distance. But as a rule the operator will utilise the whole of his lamp, and throw the maximum of obtainable illumination on the object to be examined. It is interesting to know the difference of illumination required to render visible a troop of infantry in dark uniform or the same troop as seen projected on a snowy background, but practically it can be of no great importance. The object is either seen or it is not, and the operator has very little power of adjustment. If under certain circumstances a village or a church or a submarine turret becomes visible, the inference would be that the atmosphere was transparent, if not seen, then the air was misty.

If the general formula for the range of searchlights be examined the influence of the uncertain variables in the calculation is seen more clearly. The formula, due to M. Blondel, is:

$$\epsilon_0 = \epsilon_p \frac{a^{l+l^1}}{l^2} \times j.$$

The distance in kilometres from the searchlight to the objective and from the object to the eye is expressed by l and l^1 respectively, ϵ_0 is the illumination affecting the retina after the luminous flux has traversed the range $(l + l^1)$ and ϵ_p is the illumination at the distance of 1 km. from the searchlight. The trouble or the vagueness is introduced by the symbols a and j. The former coefficient expresses the proportion of luminous flux which remains after the beam has passed through a layer of air 1 km. in thickness. Values of a are given for different climates in Europe, and the frequencies with which certain degrees of absorption may be expected on the average are worked out. We are sure that very great care has been bestowed on these estimates, but averages are of little use when the need arises to see an object at a particular moment. The coefficient j occasions still greater uncertainty, for it expresses the proportion of light reflected, or diffused, by the object illuminated, and implicitly contains the effect of contrast between the object and the background on which it is projected. This coefficient should decide the amount of light reflected from the object to the eye, and is consequently again subject to atmospheric absorption. To a certain extent the formula represents experience, and it enables us to answer such questions as, At what distance and with what illumination would a powerful searchlight render a torpedo boat visible on an average winter night? The answer is about 5,000 m. under an illumination of 0.704 lux. The searchlights that nightly sweep the sky over London probably are about this range, and the light moving over the clouds gives an idea of their distance. When the chances of picking up a Zeppelin are calculated, the diameter of the beam becomes an important factor—at a distance of 1,000 m. this diameter would be about 30 m., and the beam rapidly passes over this small space, rendering detection difficult. M. Rey's diagrams facilitate, or dispense with, calculation in finding a solution for many interesting problems connected with aerial or military work.

If the observer is, as usual, near the searchlight, the general formula is simplified by making $l = l^1$, and this case is considered at some length, with appropriate diagrams. Another limiting condition of particular interest is to make l^1 nothing. This case arises when the observer himself is the illuminated object. Instances are given in which, during military operations, pioneers in trenches and aviators aloft have been caught in the beams of a searchlight, and finding themselves illuminated with comparative brilliancy have believed that they were equally visible to the enemy. But this is a mistake, and arises from overlooking the effect of l^1 in the formula. The degree of illumination experienced by the soldiers in a trench, say, 8 km. from a searchlight, would be probably comparable to that received from the light of a full moon, or about 0.20 c.p. But this light in travelling a similar distance to the enemy would be much weakened, and an object so illuminated could only have been visible at a comparatively close range. The same formula shows that if it is desired to increase the visibility of an object, it is of greater advantage to reduce the distance between the searchlight and the object than for the observer to make a similar approach.

BOOKS RECEIVED.

Documents Governing the Construction of a Bridge, including a Reprint of the Specifications, Proposal, Contract and Bond of the Columbia River Inter-State Bridge, a Description of the Structure, and a Discussion of the Function of Specifications. By E. E. HOWARD. New York: John Wiley and Sons; London: Chapman and Hall, Limited. [Price 5s.]

The Elementary Principles of Wireless Telegraphy. By R. D. BANGAY. Part II. London: The Wireless Press, Limited. [Price 2s.]

Valuation, Depreciation and the Rate-Base. By CARL EWALD GRUNSKY, Eng.D., assisted by CARL EWALD GRUNSKY, Junr. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18s. 6d. net.]

The Range of Electric Searchlight Projectors. By JEAN REY. Translated by J. H. JOHNSON, M.Inst.E.E. London: Constable and Co., Limited. [Price 12s. 6d. net.]

Transactions of the Liverpool Engineering Society. Vol. xxxvii. Edited by THOMAS L. MILLER, M.Inst.C.E., Acting Hon. Secretary. Liverpool: Published by the Society.

Railway Maintenance Engineering, with Notes on Construction. By WILLIAM H. SELLEW, A.S.M.E. London: Constable and Co., Limited. [Price 10s. 6d. net.]

Mining and Mine Ventilation, a Practical Handbook on the Physics and Chemistry of Mine Ventilation. By JOSEPH J. WALSH. London: Constable and Co., Limited. [Price 8s. 6d. net.]

Text-Book on Motor Car Engineering. By A. GRAHAM CLARK. In two volumes. Vol. II: *Design.* London: Constable and Co., Limited. [Price 8s. 6d. net.]

Experimental Building Science. By J. LEASK MANSON, B.Sc., Eng. (Lond.). Vol. I. Cambridge: University Press. [Price 6s. net.]

Rugby Engineering Society's Proceedings, Session 1914–15. Vol. XII. Rugby: Published by the Society. [Price 10s. 6d.]

Reports of the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Vol. I, 1916. London: Published by the Society, Broadway Chambers, Westminster. [Price 5s. 6d., post free.]

ENGINEERS' UNIONS AND THE WAR.—As here, so in the States, the engineers' unions are in some cases inclined to rank their private interests above their national obligations. A Bill has been introduced in Massachusetts authorising the granting of special first-class engineers' licences during the war on the ground that conscription will produce a shortage. The Bill is opposed by the engineers' unions, who contend that a surplus of men holding first-class licences now exists, and that the granting of temporary first-class licences, even with examinations as to competency, will lower the standard and prove dangerous to the public.

INDUSTRIAL NOTES.

THE question of education is dealt with in the *Brotherhood of Locomotive Firemen and Enginemen's Magazine*, Chicago. The magazine finds that owing to the deplorable tendency of American communities to follow the phantom of wealth—to get something for nothing—many universities and colleges have been endowed by men of the Rockefeller and Carnegie type, who through a deplorably defective and unjust economic system have become possessed of fabulous wealth. The result is that members of the faculties of those institutions have acquired an attitude of sycophantic servility towards them and eagerness to aid them in attaining their purposes irrespective of the consequences to human rights or liberties. Hence the youths educated in such institutions are trained to uphold the ascendency of the powers of wealth and privilege, and are saturated with the idea that the masses of the common people should be submissively subservient to the ruling class, the master class. All colleges, the magazine says, should be maintained at public expense exclusively, and they should all operate to inculcate in the minds of their students principles of liberty, equality and fraternity, instead of being used as the personal instrumentalities of the over-rich to propagate ideas and tendencies in conflict with those principles. The journal from which we quote finds that conditions are not much better in the common schools. The public schools, it adds, belong to the people, and yet how many public schools in the United States are open for community meetings in the evenings or are at any time available for assemblages of the common people for the discussion of questions of public interest—and so forth.

In regard to this latter part of the contention made by the American magazine, common-sense precludes the free use of public buildings for the propaganda of any political party, whether it be—as is usually the case—a minority, or even when a majority. Halls can always be hired for that purpose. In regard to men like Mr. Carnegie, success is by no means the fortunate accident assumed in the article under criticism. Many men started in the steel business under even more favourable conditions than he, and came to grief. Mr. Carnegie's success was due in the main to his mental qualities, amongst which stood prominent his readiness to recognise the value of intellect and to reward it accordingly.

It would be interesting to have the views of the writer of the article referred to on the enormous salary which the "masses" provide to "Charlie Chaplin," a salary which is said to be some tens of thousands sterling per annum. Almost the whole of this is freely furnished by the working classes, who are the main patrons of the cinema, and who have by their support automatically fixed the value they place on his services. Certainly he cannot be accused of exploiting labour, as no one need attend a cinema theatre unless he so chooses. Again, "Jack London" received 5,000*l.* per annum for serial rights in his stories. The theory that all large fortunes are due to robbery only needs to be examined to be abandoned. The moralist and the philosopher may consider that the services of both these two latter plutocrats have been greatly overvalued, but the public, by acts which are more emphatic than words, is obviously of a very different opinion.

Speaking at a meeting in London, last Sunday, Mr. C. W. Bowerman, M.P., referred to his recent visit to the United States and Canada, and said that one of the things which struck him most in connection with the labour councils in America was the fact that millionaires and great capitalists sat side by side with representatives of labour for a common end. It was the first time, he added, that capital and labour in America had ever so conferred. It showed that the American nation as a whole was fully determined in regard to the war now that it had entered the conflict. The feeling of America towards the war was one of intense enthusiasm, dead earnestness, and grim determination. The successful dealing with the German and Austrian elements in the United States was largely due to the courage and determination of the American working classes in the support they gave the Government. Mr. Bowerman further stated that as soon as war was declared by America the German and Austrian workmen in munition factories, who had hitherto asked to be allowed not to take part in the making of munitions for the Allies, changed their attitude entirely and requested to be allowed to share in the work.

In replying a few days ago to a resolution recently passed by the Bury Trades Council, Mr. John Hodge, the Minister of Labour, stated the following :—

"I am in receipt of the resolution of condemnation relating to my remarks on the recent industrial unrest in the engineering industry, passed by the Bury Trades and Labour Council.

"I am afraid your members have misapprehended the purport of some of my statements. They alluded, not to causes of industrial unrest, but to those responsible for resorting to unconstitutional methods in the midst of a grave national crisis. I have had over 30 years trade union experience and I know only too well that the causes of grave industrial discontent are almost invariably due to grievances connected with working conditions.

"I do not think that the recent stoppage was an exception to this general rule, and I am just as anxious as you may be that all legitimate grievances should be remedied as far as possible, but I do most strongly deprecate the use of unconstitutional methods in the midst of a great war as the means of securing redress for such grievances. The inevitable result is to restrict and impede the output of munitions which are so essential to the successful prosecution of the war by our soldiers at the front. I am satisfied that the majority of workmen share this opinion."

An interesting feature of the visit paid by about 60 members of the Midland Section of the Coke Oven Managers' Association to the Thorncliffe and Rockingham works of Messrs. Newton, Chambers and Co., Ltd., on Saturday, June 30th, was, says *The Sheffield Daily Telegraph*, the announcement of a cheap power project made by Mr. W. Hay (general manager of the collieries) in the course of a welcome he extended to the visitors.

Mr. Hay reminded the coke oven managers that upon them depended in a very large measure the future prosperity of the nation. The collieries produced for them a substance of almost unknown possibilities, and it was for those connected with the coke oven industry to manipulate that product to the fullest advantage. Sometimes scientific gentlemen were inclined to be forgetful of the commercial aspect of the industry. Directors, on the other hand, had to look at their concerns purely as a commercial proposition. There was no doubt that in the past the coke oven undertaking had been fairly remunerative, but what was in store for it it was not easy to foretell. He hoped the future of the industry was more promising than it appeared to him. They had had in the past a great deal of competition with Germany, and the question was: Was that going to continue? If coke oven enterprises in this country could find a market for their products, and especially if the farmers could be persuaded to take more of their commodities, and foreign competition could be kept out, he believed the industry might succeed, but if once they opened the door to free trade he was not very sanguine about the coke oven industry in this country.

They had got high-temperature distillation to a high state of efficiency, and they could now devote their leisure to the study of low-temperature problems. In order to get the various fractions from low-temperature distillation they might have to put down very costly plant. He had been told within the past few days that some people of high standing in the commercial world had been approached in connection with a projected expenditure of 2,000,000*l.* upon a low-temperature distillation plant, from which the supply of gas would enable them to produce power at 0·2 of a penny per unit. That project had been seriously put forward before certain people not very far distant from Sheffield. Some idea of the gigantic nature of the undertaking would be gathered from the fact that the gas would be conveyed in a pipe of 15 ft. diameter. He could assure them that it was seriously proposed that 2,000,000*l.* should be subscribed for the development of low-temperature distillation plant, and possible users of the power had been told that they could have it at 0·2*d.* per unit.

The Controller of Coal Mines, Board of Trade, has been advised that an economy in the use of coal can be effected and much inconvenience avoided during the next and succeeding winter by giving effect as far as possible to the following suggestions :—

1. *Power Uses.*—That the various factory owners throughout the country who at present generate their own power by means of coal should make arrangements for taking their power requirements from an outside source in districts where the power supplies have a margin available, and thereby reduce the total amount of coal used. The Coal Controller will assist as far as possible in obtaining priority for plant, machinery and motors required, provided a substantial coal saving can be demonstrated.

2. *Use of Coke.*—The use of locally produced coke or coke breeze in place of coal as much as possible in domestic grates, factory furnaces (where such cannot take an outside supply), public utility plants at light loads, also in baths and wash-houses, provided coke is available in sufficient quantities.

3. *Public Services.*—The curtailment of those public services which entail coal consumption, such as early and late tramway running—after consultation with the Ministry of Munitions where munitions workers are likely to be affected—and the prevention of unnecessary use of water.

4. *Stocks.*—The accumulation of stocks in the summer months, as far as deliveries will permit, of the coal required during the winter months, the cost of such storage being considered as a form of insurance against the probable coal shortage.

5. *Cooking and Heating.*—The installation of gas or electric cooking and heating appliances in public and private buildings, with a view of saving coal generally and lessening the serious inconvenience to the public next winter should the local distribution of coal become irregular or insufficient.

6. *Emergency Disconnection.*—The application to the Board of Trade by the Electric Supply Authority for sanction under Regulation B. 1 to disconnect classes of non-essential consumers in cases of urgent necessity in order to enable the supply to be continued to munition and other essential users. This power should be obtained, although it need not be put into execution until the necessity arises.

7. *Interconnection.*—Making arrangements, as suggested in the letter of the Board of Trade dated May 25, 1916, with the neighbouring towns to interconnect electric distribution systems or generating plants by means of underground cables or, in suitable cases, of temporary overhead wires over the intervening country, so as to enable one or two of the most economical power stations in each district to supply several towns at light loads instead of each town having to run its own power station uneconomically at such times. This would also enable the various power plants to shut down in turn during week-ends and holidays to effect plant repairs, and would provide some amount of power at call as a stand-by in case of coal supplies giving out locally.

In order to carry out the last suggestion the Controller is advised that additional powers will have, in some cases, to be obtained both as regards passing over private property and trading between public utility companies and local authorities and possibly relief from some of the existing power supply regulations; and if cases are brought to his notice they will receive his assistance where the saving in coal would warrant the provision of the necessary plant, mains, &c.

According to data issued by the Malayan States Information Agency, 88, Cannon Street, E.C. 4, there were no labour troubles or disturbances in the Federated Malay States during 1916. Shortage and increased cost of labour was complained of, and was said to be due to mining labour taking to the cultivation of rubber. The total labour force employed on mining at the end of the year was 139,143 (all of whom, with the exception of 1,067 men, were employed on tin mining), as against 164,457 in 1915 and 171,689 in 1914. Of the miners, 132,053 were Chinese, 4,921 Indians, and 1,904 Malays. There were 197 Europeans employed in supervision at the mines.

It is reported, says *The London and China Telegraph*, that many employees of the Mitsu Bishi Dockyard are leaving Nagasaki in order to obtain work at higher wages in other shipbuilding establishments, the demand for skilled labour greatly exceeding the supply. According to one report the Osaka Iron Works contemplates securing 300 men from the neighbourhood for its workshops in Hiroshima-ken. The Mitsu Bishi Dockyard officials are greatly concerned, and are taking steps to check the departure of their men. The establishment of a shipbuilding yard at Yokohama by Mr. Asano, president of the Toyo Kisen Kaisha, is largely responsible for the present demand for skilled labour, and large numbers of men have left the employ of the Mitsu Bishi Company, the Kawasaki Dockyard, and the Osaka Iron Works to join the Asano undertaking.

FUEL SUPPLY IN BRITISH MALAYA.—The supply of coal was a source of anxiety until the Malayan collieries got into full work, says the Malayan States Information Agency. The existence of a local colliery obviated a serious shortage of coal. The consumption of wood fuel showed an increase. Work was carried on at the Malayan collieries throughout the year (1916), but for some time the output was restricted owing to a "want" having been encountered in the North Mine. Shortage of labour and certain essential supplies tended to restrict the extension of operations. The output was 101,846 tons. In the North Mine the main haulage way is down 1,300 ft. on the slope, and in the South Mine 1,200 ft. The power-house capacity is to be increased by 600 kw.: air compressors, compressed air operating plant, ventilating plant, and other machines are under order. Experiments are in progress in England on distillation of the coal with a view to valuation of by-products, but nothing definite has been arrived at with regard to briquetting, and it is most important that this should be dealt with as soon as possible. It is essential that material for filling should be obtained, and the management is making investigations with regard to material for hydraulic filling. Tests of this coal in Crossley's suction-gas plant gave a consumption of 1¼ lb. per brake horse-power hour.

COBALTCROM, THE NEW STEEL ALLOY.

WIDESPREAD interest has been aroused by the announcement on behalf of Messrs. Darwin and Milner, of Sheffield, of the discovery of a tool steel stated to be equal in durability and hardness to high-speed steel, yet of which tungsten is not a component. "Cobaltcrom," as the new steel is called, is the outcome of much experiment and labour, extending over many years, on the part of the head of the firm of Darwin and Milner. He had long been experimenting in the direction of finding a steel which could be made without tungsten but would possess the necessary hardness of the so-called "high-speed" steels. About twelve months ago he discovered that by adding cobalt to chromium-carbon steel he converted a steel which had no appreciable red-cutting hardness into one which had this very valuable qualification.

It is a fairly well known fact that while tungsten high-speed steel has for some years past been extensively used for turning, planing and slotting tools, it has not been used so largely for milling cutters, taps, reamers, &c. It is estimated by Messrs. Darwin and Milner that of all the milling cutters, &c., used in the engineering world, at least 90 per cent. are still being manufactured from carbon steel, whereas, on the other hand, the reverse is the case with turning tools, nine-tenths of which are made from tungsten high-speed steel. In the opinion of the firm the reason that high-speed steel has not been applied largely for milling cutters, taps, &c., lies in the difficulty which the tool-maker experiences in hardening such tools having fine edges at the high heat required to secure from tungsten high-speed steel its best cutting efficiency. Tungsten high-speed steel requires hardening at from 1,250 deg. to 1,350 deg. C. if the best results are desired. To try and obtain this heat for milling cutters is very risky, and to harden at a lower heat gives less satisfactory results.

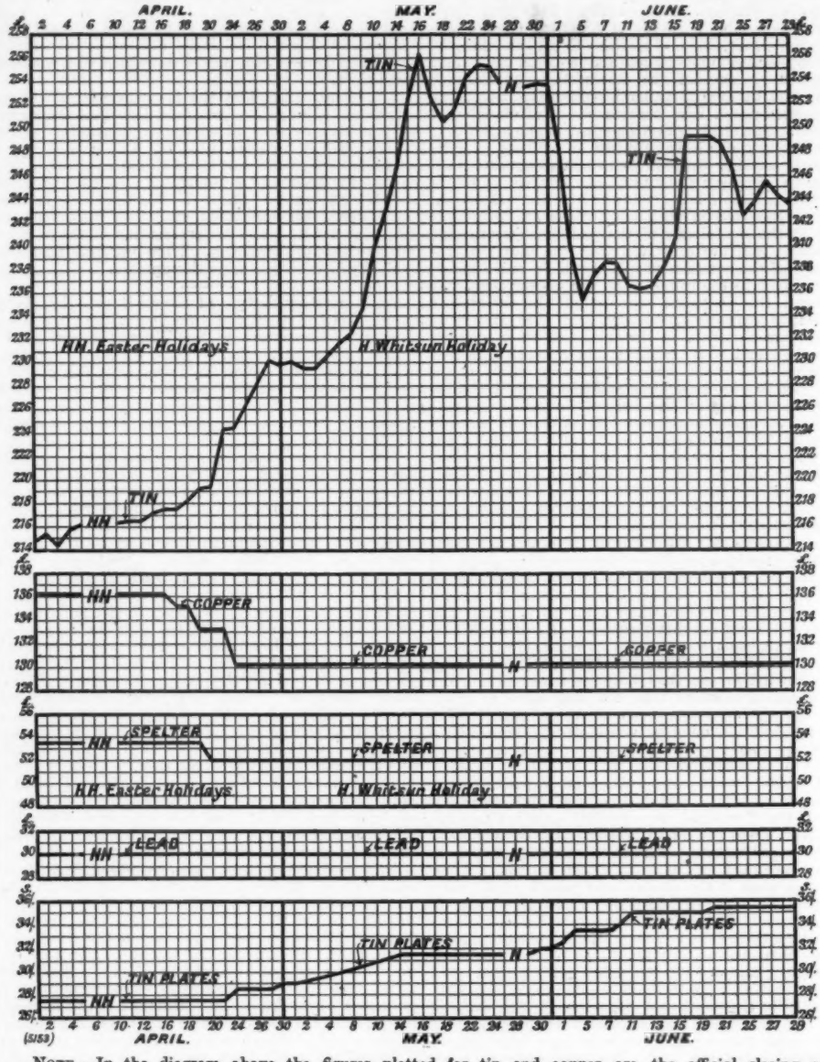
When the war broke out Sheffield firms received instructions that they must make milling cutters and taps from the very best high-speed steel, but there was endless trouble through the hardening process alone, with the result that carbon steel was soon substituted. Now it has been found that the maximum heat necessary for the hardening of the new steel is only 1,000 deg. C. As a matter of fact, if this heat is exceeded the tools give adverse results. This temperature allows of the manufacture of fine-edge tools of a perfectly satisfactory character with the red-cutting hardness of the tungsten high-speed steel. Hardening in practically all applications is stated to be satisfactory when the tool is allowed to cool naturally in still air free from draughts and currents, whereas with the tungsten high-speed steel, hardening from the extreme high heat renders it necessary to quench either with a strong air blast or a sudden immersion in liquid. Messrs. Darwin and Milner state that with the new steel it is possible to get absolutely the same standard of hardness throughout.

Samples of the steel have been tested in a large number of important works throughout the country, and have shown that the cobaltcrom is specially suitable for milling cutters, twist drills, reamers, taps, automatic forming tools, screw cutting, finishing tools generally, for machining gun-metal and yellow metals, as well as for high-endurance drawing and blanking dies, lathe centres, shear blades, aeroplane and automobile combustion-engine valves, and every description of gauges and instruments which have to resist abrasion. A test has been made showing that with a carbon steel blade saws can cut for half a day, with a tungsten high-speed steel blade for two days, but with the new steel four days without the need of grinding. We are informed also that particulars have come to hand of tests made in America between the new steel and the Becker iridium-cobalt-tungsten high-speed steel, these proving the tungstenless steel to be the equal of the famous American product.

Messrs. Darwin and Milner have applied for patent rights the world over, including, by permission of the Patent Office authorities, Germany and Austria. A point which should not be overlooked is that the cutting efficiency of the new steel is quite equal, even in the form of castings, to that of tools made from the forged or rolled bar in which high-speed steel is supplied commercially, and as the material in the molten state is much more liquid than high-speed steel, it lends itself to all forms of tool-form castings. We are informed that the makers are preparing to put into operation an organisation to supply orders for milling cutter blanks in this new steel within 48 hours, and this should be of great assistance to engineering concerns in times like the present.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets).

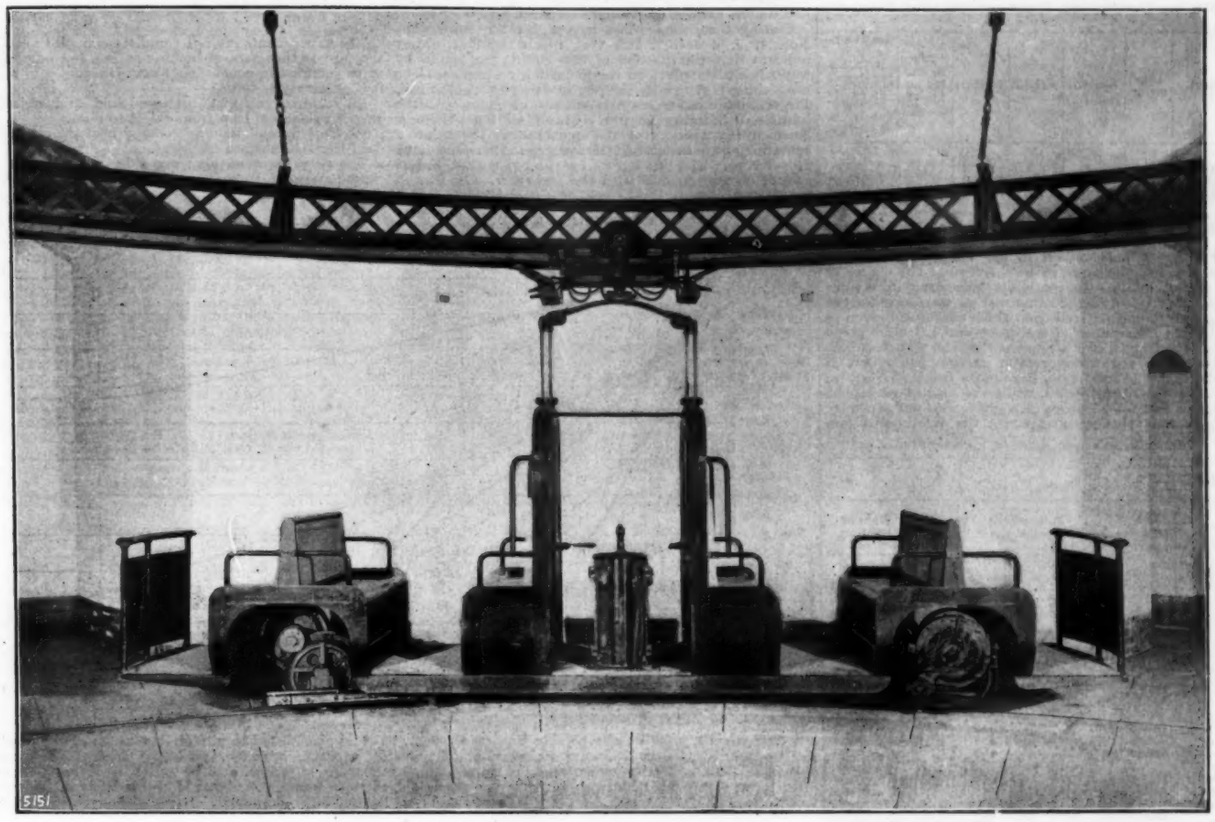


NOTE.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

BOARD OF TRADE CONSULTATIVE COMMITTEE ON COMMERCIAL INTELLIGENCE.—A meeting of the Advisory Committee to the Board of Trade on Commercial Intelligence was held at the Board of Trade on the 4th inst. Sir H. Llewellyn Smith presided, and there were also present Sir F. Forbes Adam, Sir A. E. Bateman, Sir Hugh Bell, Sir Henry Birchenough, Sir W. H. Clark, Mr. T. Craig Brown, Mr. H. Fountain, Mr. C. A. Harris (Colonial Office), Mr. A. J. Hobson, Mr. L. J. Kershaw (India Office), Mr. Henry Lambert (Colonial Office), Mr. E. H. Langdon, Mr. Stanley Machin, Sir Thomas Mackenzie, Mr. J. W. Murray, Sir E. Parkes, M.P., Sir Hallewell Rogers, Sir A. Spicer, Bart., M.P., Mr. Robert Thompson, M.P., Mr. Victor Wellesey (Foreign Office), and Mr. Percy Ashley (secretary). A report was presented on the work of the Department of Commercial Intelligence during the quarter ended June 30, and among the other matters considered by the committee were the future organisation and scope of the British Industries Fair, co-operation of the Board of Trade with trade associations in the investigation of foreign markets, the revised instructions to trade commissioners, the Commercial Mission now in progress in Spain, and proposals for the formation of a Latin-American association

PUBLIC TRADING VENTURES.—The Committee on Retrenchment in the public expenditure has reported that of all the numerous services managed by the Post Office, hardly one shows any profit except the letter post. "The State telephone service," it says, "is a more recent acquisition. Part of the present system was built up by the Post Office; part was acquired by purchase from the National Telephone Company in 1911. The profit now derived from the whole system appears to be less than the payment which the National Telephone Company used to make by way of royalty to the State." We may add that on acquiring the company's undertaking the State refused, save in exceptional cases, to retain the services of any employee whose salary was 700*l.* a year or more. Brains are the last thing that a Government considers necessary, and the more democratic the Government the lower the value it places on intellect. The usual plan on taking over a public utility or on reorganising an existing department is to reduce the number of officers paid highly because they are expected to exercise initiative, the whole of which sooner or later thus gets concentrated in the hands of a single individual. The overwhelming amount of work thus concentrated on one pair of shoulders tends to make the office suitable only to an industrious clerk, rather than to someone of an original and enterprising type of mind. It will be noted that whilst our railway companies often appoint engineers as their general managers, the special heads of even the technical services of the Government are invariably clerks. The Mesopotamia report is the natural outcome of a condition of service in which promotion depends mainly on the literary ability necessary to write a readable report.

ELECTRIC MONORAIL CAR; GOVERNMENT SUBWAY, WASHINGTON.



THE GOVERNMENT SUBWAY AT WASHINGTON.

By R. W. A. SALTER.

IN 1906, when the Senate Building in Washington, D.C., was nearing completion, it was decided that a subway beneath the park area adjoining the Capitol was desirable. This idea was acted upon. At first senators were satisfied to walk through this subway, but that was found to be too slow, especially when they were hurrying from their offices to the Senate Chamber to vote. Consequently an electric car, with capacity for about 12 persons, was placed in service. This also proved too slow after a time. Then a monorail car was installed, but even this was not fast enough, and now the electrically-driven monorail car, of which an illustration is given above, has been put into operation.

This car is designed to carry 12 people, the operator taking his seat in the centre, where a controller may be seen. The driving power consists of a direct-current motor, 7½ h.p., geared, as will be noted from the photograph reproduced, to the driving wheel of a small truck under each end of the car, each truck being king-pin swivelled to allow for easy operation on the curves. The overhead construction consists of a combination of light steelwork as shown, and overhead wooden beams running along the ceiling of the subway. The lower member of this overhead work is a 4-in. by 8-in. white pine stringer, on each side of which is placed a 3-in. by 3-in. angle, the lower faces of these angles being used as the contacts for the current, which is furnished at 125 volts pressure. The middle wheel shown on the photograph has a duplicate on the other side. These two wheels are of steel, covered with a cotton travelling surface of special character, and each travels on the upper surface of the projecting angle, sustaining the weight of the overhead structure of the car. The two wheels on either side of each main carrying wheel, as shown edgewise in the photograph, serve as anti-friction rollers against the sides of the wooden member above the angles. The brushes are shown at an angle from each end of the upper structure. Below this is a yoke fastened to two 3½-in. Shelby steel tube plungers working in sockets, the heads of which are shown and which are part of the rigid car construction. The counterbalance hidden by this construction relieves the overhead weight up to within about 60 lb. The plungers carry two guides attached, which move up and down in conjunction with them and carry the positive and negative contacts for the current received from the controller. The connection to the overhead brushes is made through the interior of the tubing and over the yoke to the brushes, the latter portion of which is shown.

The seats of the car are upholstered in wooden canework of the type used in ordinary office chairs. Apart from this and the wooden frames retaining it, and the covering of the floor, the car is built entirely of steel. The single rail used which forms the two tracks and the loop is of about 30 lb. to the yard, steel, and of the ordinary American railway type. The car makes about 125 trips per day, the length of the track being 750 ft.

All the details of the above car were worked out under the direct supervision of Mr. Elliott Woods, superintendent of the Capitol Building and Grounds in Washington, D.C., while the actual construction was carried out by the ordnance department of the Washington Navy Yard.

NOTES ON SOME QUENCHING EXPERIMENTS.*

By LAWFORD H. FRY (Burnham, Pa, U.S.A.).

THE experiments to be described were carried out to study the rate of cooling in various quenching media, and to try to connect the rate of cooling with the physical properties obtainable in quenched and tempered forgings.

The main series of experiments was carried out with two locomotive driving axles, which were drilled so that a pyrometer could be inserted and the temperature of the axle measured continuously during the process of quenching. One axle was 11 in. in diameter, was forged solid, and weighed 1,830 lb. The other axle was 12 in. in diameter, bored longitudinally with a 3-in. hole, and weighed 2,000 lb. To measure the temperature a hole for a pyrometer was bored in one end of each axle to a depth of about 15 in. parallel to the longitudinal axis. In the solid axle the hole was half-way between the centre and the outside of the axle, while in the bored axle it was half-way between the surface of the bore and the surface of the axle. The pyrometer used was a base metal thermocouple fitted with a plug which was driven into the outer end of the hole so that the quenching medium could not enter and the actual temperature of the interior of the axle could be measured. In carrying out the experiments the axle was heated uniformly as though for quenching in the usual course of manufacture, then withdrawn from the furnace and the pyrometer inserted. A wait of about two minutes was made for the thermocouple to take the temperature of the axle, and the axle then quenched. As the temperature fell, readings were taken at short intervals, and temperature-time curves were plotted as in Fig. 1 overleaf. The quenching media experimented with were air, water, a heavy oil of 26 deg., a light oil of 29 deg. Beaume gravity, and three strengths of a cutting compound dissolved in water. This cutting compound, which was composed of mineralised lard oil and soft soap, was first used in a 50 per cent. solution, that is equal parts of compound and water. It was then diluted to a 33 per cent. solution, that is, one part compound to two of water, and was finally diluted to a 25 per cent. solution, one part compound to three of water. The cooling curves for 12 experiments are given in Fig. 1, eight being made with the solid and four with the bored axle, as shown below :—

Number of Curve on Plot.	Kind of Axle.	Quenching Medium.
1	Solid axle	Air.
2	,,	Heavy oil.
12	,,	Light oil.
10	,,	Water.
6	,,	50 per cent. solution.
4	,,	50 ,, ,,
5	,,	33 ,, ,,
7	,,	33 ,, ,,
3	Bored axle	Heavy oil.
9	,,	33 per cent. solution.
8	,,	25 ,, ,,
11	,,	25 ,, stirred by air.

These curves permit comparisons between the rates at which the various media abstract heat, and also throw some light on the influence which the form of the object quenched has on its rate of cooling.

Influence of Form of Object on Rate of Cooling.—It is obvious from the curves that the bored axle cooled

* Paper read before the Iron and Steel Institute in London.

more rapidly than did the solid axle in the same medium. This is due to the greater surface exposed to cooling for each pound of weight. A direct comparison of the two axles is facilitated by Tables I and II, which also include particulars of some experiments in which the cooling rate

TABLE I.—*Comparative Dimensions of Test-Piece and Axle.*

Object.	Diameter.	Length.	Weight.	Surface.	Surface in Sq. In. per Lb. of Weight.	Heat Capacity in B.Th.U. per Degree of Temperature per Sq. In. of Surface.
	in.	in.	lb.	sq. in.		
Test-piece	1¼	5	1.6	22	13.5	0.0085
Bored axle	12	65	2,000	3,270	1.63	0.070
Solid axle	11	66	1,830	2,540	1.39	0.082

of a small test-piece was measured. This test-piece was 1¼ in. in diameter by 5 in. in length, with a weight of 1.6 lb. A hole drilled in one end along the axis enabled a thermocouple to be inserted at the centre of the piece. Cooling curves while quenching in various media were taken in the same way as was done for the axles, and figures derived from these curves are given in Table II. Dimensions of test-piece and axles are given in Table I, from which it appears that the test-piece had practically a ten times greater surface per pound of weight than the solid axle, the figures being 13.5 sq. in. and 1.39 sq. in. per pound, while the rate at which the test-piece lost temperature in a given medium was very close to ten times that at which the axle cooled (see

TABLE II.—*Cooling Rates in Various Media.*

1.	2.	3.	4.	5.	6.	7.	8.
Cooling Medium.	Object Cooled.	Fall of Temperature.			Time of Cooling in Min.	Rate of Cooling.	
		From Deg. F.	To Deg. F.	Drop Deg. F.		Deg. per Minute.	B.Th.U. per Sq. In. of Surface per Minute.
Air ..	Test-piece	1,450	1,290	160	1.3	120	1.0
,, ..	Solid axle	1,450	1,290	160	16.0	10	0.8
Heavy oil	Test-piece	1,460	850	610	1.7	350	3.0
,,	Bored axle	1,450	850	600	15.5	39	2.7
,,	Solid axle	1,450	850	600	26.0	23	1.9
Cutting compound	Test-piece	1,450	800	650	1.3	500	4.2
,,	Bored axle	1,450	800	650	16.0	40	2.8
,,	Solid axle	1,450	800	650	18.0	36	3.0
Water ..	Test-piece	1,450	700	750	0.9	820	6.9
,, ..	Solid axle	1,450	700	750	9.0	82	6.8
Light oil ..	Solid axle	1,350	850	500	11.5	44	3.6

column 7, Table II). This means that in a given medium the heat is given up by the axle and by the test-piece at practically the same rate in British thermal units per square inch of surface. The closeness with which this holds can be seen from column 8 of Table II. When the great difference in size of the object is taken into consideration, the fact that the cooling rates are so nearly the same is remarkable. It seems that fairly accurate information as to the quenching properties of a medium can be obtained from small-scale experiments.

In any such work it must of course be remembered that the physical properties of steel are determined not by the rate at which the heat is lost per unit of surface, but by the rate at which heat is lost per unit of weight, that is by the rate at which temperature is lost. Referring to Table II, the rate at which heat is lost per unit of surface (column 8) is determined by the quenching medium, while the physical properties of the steel are determined by the rate at which the temperature is lost (column 7). This rate of temperature loss depends both on the quenching medium and on the form of object quenched, the latter being the more important factor.

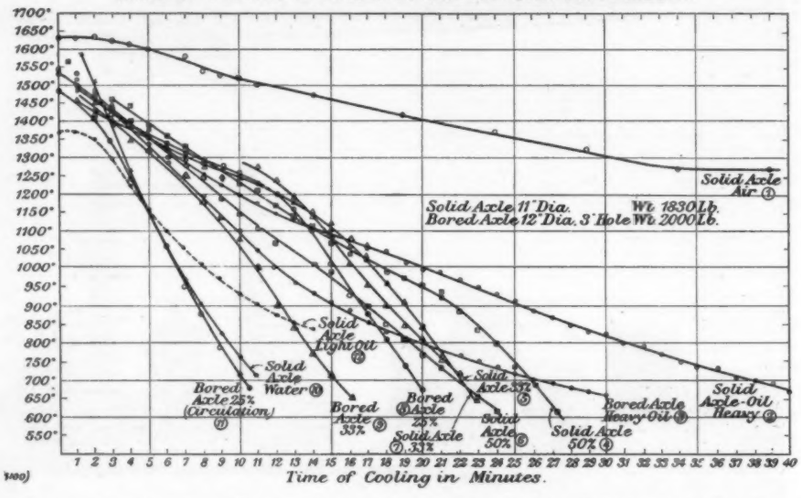
This being the case it is necessary, in any discussion of the physical properties of steel in connection with heat treatment, to define not only the cooling medium, but the size of the piece cooled. This point was made by the author before the American Society for Testing Materials in June, 1916, and is also dealt with in Stead's recent paper on "Mechanical Properties of Steel." The only scientific method of defining heat treatment in connection with physical properties is not to speak of "water quenching" or "air coo'ing," but to give the rate of temperature loss over a given range, as is done, for example, by Howe and Levy in their "Notes on Pearlite."*

To appreciate the indefinite nature of the expression "air-cooled" it is only necessary to compare the cooling rates of the test-piece and the axle in Table II. The test-piece lost heat at the rate of 120 deg. per minute, and although the rate of cooling would be somewhat slower if it were averaged over a longer temperature range so as to include the recalescent period, it will be seen that the rate at which the test-piece cools in the air is of the same order as the rate at which the axle cools when quenched in water. Consequently the physical properties of the "air-cooled" test-piece and of the "air-cooled" axle will differ as widely as the properties of the air-cooled axle and of the water-quenched axle.

Quenching Speed and Composition of Medium. Heavy Oil.—Curves 2 and 3 in the figure below show respectively the cooling rates for the solid and the bored axle and do not call for individual comment.

Cutting Compound.—The curves for the solid axle, Nos. 4, 5, 6 and 7, fall very much together. They indicate that the dilution of the cutting compound by water has little effect on its quenching properties. The same thing is shown by the physical properties obtained. There is more difference between two quenches with the solution containing 50 per cent. of oil than there is between the average of the quenches in the solution containing 50 per cent. and the average in that containing 25 per cent. The two curves for the bored axle, Nos. 8 and 9, do not conflict with the foregoing. In fact in

RATE OF COOLING OF AXLES IN VARIOUS QUENCHING MEDIA.


Solid Axle Air ①
Solid Axle 11" Dia. Wt 1830 Lb.
Bored Axle 12" Dia. 3" Hole Wt 2000 Lb.
Solid Axle Light Oil ②
Solid Axle Water ⑧
Bored Axle 25% (Circulation) ⑦
Bored Axle 33% ⑤
Bored Axle 25% Solid Axle 33% ⑥
Solid Axle 50% ⑥
Solid Axle 33% ⑤
Solid Axle 50% ④
Bored Axle Heavy Oil ③
Solid Axle Oil Heavy ②
Time of Cooling in Minutes.

the 33 per cent. solution the cooling was considerably more rapid than in the 25 per cent. solution. Tensile tests from the two axles represented by these curves, after being drawn at 1,100 deg. F., gave the following results :—

No. of Curve on Plot	Quenching Medium	Minutes to Cool from 1,450 deg. F.	Elastic Limit.		Tensile Strength.		Elongation in 2 in.	Reduction of Area.
	Per cent. Solution.		Lb. per Sq. In.	Tons per Sq. In.	Lb. per Sq. In.	Tons per Sq. In.	Per cent.	Per cent.
8	25	16.1	40,500	18.1	78,000	34.8	29.0	55.0
9	33	13.6	43,000	19.7	81,500	36.4	30.0	53.5

These figures suggest that the axle giving curve No. 9 did, for some reason, cool more rapidly than that of curve No. 8. It is possible that the explanation is to be found in some local condition affecting the convection in the bath.

Curve No. 11 is made from the same axle and the same 25 per cent. quenching medium as used for curve No. 8, but a jet of compressed air was introduced into the bath so as to give a vigorous circulation to the quenching medium. The effect in increasing the rapidity of cooling is very marked. The time required for the temperature to fall from 1,450 deg. F. to 800 deg. F. was reduced from 16 minutes with the bath stationary to 9 minutes with the bath agitated by air, the rate of temperature fall being increased from 40 deg. to 72 deg. per minute, that is, by 80 per cent. The physical properties show a corresponding improvement. The figures above show the tensile properties obtained with carbon steel and with chrome-vanadium steel axles quenched in the 25 per cent. solution first without agitation and secondly with agitation.

Water.—Curve 10 shows the cooling of the solid axle in water. The heat is lost at a rate slightly faster than in the case with the bored axle in the cutting compound with air circulation.

Taking the results in general the rates of cooling of the solid axle weighing 1,830 lb., and having about 1.4 sq. in. per pound of weight, may be given in round figures as follow :—

	Deg. F. per Minute.
In air	10
In heavy oil, 26 deg. B.	25
In oil solution	35
In light oil, 29 deg. B.	45
In water	80

The experiments are not complete enough to establish a complete theory of quenching action, but one appears to be justified in concluding that for rapidity of cooling it is necessary to have :—

(*a*) Intimate contact between fluid and object, to permit transfer of heat from object to fluid.

(*b*) Free flow of fluid to remove heated or vaporised fluid from the surface of object.

The effective quenching given by water is due to a combination of these two factors, aided doubtless by its high specific heat and high latent heat of vaporisation It appears, however, that the high heat-absorbing capacity of water can be offset if intimate contact between water and object is hindered, as in the case of the cutting compound. Here, although 75 per cent. of the quenching medium is water, and the viscosity is low, allowing free convection, the quenching rate is less than half that of water, so long as no forced circulation is provided. It is known that an oil film on the heating surface of a boiler will reduce the transfer of heat to the water, and it seems probable that a similar effect prevents the transfer of the heat to the bath from the object to be quenched.

Type of Steel.	Condition of Bath.	Temperatures.		Elastic Limit.		Tensile Strength.		Elongation in 2 in.	Reduction of Area.
		Quench.	Draw.	Lb. per Sq. In.	Tons per Sq. In.	Lb. per Sq. In.	Tons per Sq. In		
		deg. F.	deg. F.						
Carbon ..	Still ..	1,500	1,150	49,500	22.09	95,000	42.41	20.5	43.5
,, ..	Agitated ..	1,500	1,150	68,800	30.89	105,300	47.90	21.0	42.0
Chrome-Va.	Still ..	1,500	1,150	80,500	35.93	123,500	55.13	20.5	57.5
,,	Agitated ..	1,500	1,150	96,000	42.85	124,000	55.35	16.5	61.5

The great acceleration in cooling produced by a forced agitation of the solution is noteworthy. It is not certain how far the same action can be obtained with a pure oil such as the light oil of curve 12, but the author hopes to be able to carry out further experiments to settle this question.

The more rapid cooling produced with the light oil in comparison with the heavy oil is evidently due to the greater fluidity of the former, which enables more rapid convection currents to be set up and to carry off the heat.

BOARD OF TRADE COMMITTEE ON ELECTRIC POWER.—We are informed by the Board of Trade that Sir Archibald Williamson, Bart., M.P., has consented to act as chairman of the Committee on Electric Power, in place of the Right Hon. F. Huth Jackson, who has resigned on medical grounds, and that the following representatives of local authorities owning electric supply undertakings have been added to the committee, viz.: Mr. W. B. Smith, Mr. Harold Dickinson, and Mr. E. F. Vesey Knox, K.C.

* Journal of the Iron and Steel Institute, 1916, No. II, page 210.

THE HARDENING OF STEEL BY CHROMIUM AND COPPER.

*The Penetration of the Hardening Effect in Chromium and Copper Steels.**

By L. GRENET (Firminy).

THE minimum rate of cooling required to render the influence of quenching efficacious varies to an enormous extent, according to the quality of the steels concerned. The rate of cooling necessary to secure the hardening of special steels is lower than that necessary to secure the hardening of ordinary carbon steels. The penetrative influence of heat treatment is, therefore, more efficacious in the case of special steels than in carbon steels, and this, as is well known, constitutes one of the chief characteristics of the special steels. The difference between the influence of the heat treatment at the surface and in the centre of steel pieces, which is very considerable in the case of carbon steels but small in steels in which the hardening effect has penetrated deeply, justifies the stipulation which, for some time past, has been introduced into specifications to the effect that after hardening, but before the removal of the pieces for testing, the ends of certain pieces, such as gun parts, should be cropped. As a further consequence of the ease with which the special steels can be tempered, it is possible to harden certain of them by mild quenching operations such as oil and air tempering, which occasion little deformation or cracking. The copper steels have already been investigated, notably by Brustlein in France and by Stead in England. The present author has devoted himself more especially to ascertaining the influence of copper on the depth of the hardening effect, particularly in the presence of chromium. His experiments have been made on crucible steels from Firminy. The more interesting results have been summarised in Tables I, II and III. The following facts have been observed in this connection.

TABLE I.—ANALYSES OF THE STEELS INVESTIGATED.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	No. 15.
Carbon	0.59	0.57	0.31	0.37	0.36	0.38	0.34	0.35	0.35	0.40	0.62	0.51	0.37	0.38	0.47
Silicon	0.19	0.33	0.34	0.14	0.14	0.12	0.20	0.15	0.18	0.16	0.17	0.23	0.17	0.23	0.20
Manganese	0.54	0.60	0.46	0.26	0.20	0.19	0.28	0.21	0.22	0.24	0.61	0.38	0.57	0.36	0.36
Chromium	1.82	1.77	1.46	1.74	1.61	1.49	1.60	1.52	1.38	1.69	1.51	1.49	0.41	0.47	1.84
Nickel	0.00	0.00	0.00	0.00	2.16	2.90	3.93	2.02	2.60	2.52	2.37	1.80	2.62	1.60	3.30
Copper	0.00	1.15	0.00	4.14	0.00	0.00	0.00	2.40	2.15	4.04	0.00	1.00	0.00	1.40	1.24

These steels contain traces only of phosphorus and sulphur. They all underwent the transformation on heating below 775 deg. Quenched in water from a temperature of 790 deg., small parts showed Brinell hardnesses of 600 and upwards.

TABLE IV.—TENSILE AND SHOCK TESTS ON CHROMIUM-NICKEL STEELS AND ON CHROMIUM-COPPER STEELS WITH OR WITHOUT NICKEL.

Steel.	Temperature of Tempering.	Elastic Limit. Kg. per Sq. Mm.	Tensile Strength. Kg. per Sq. Mm.	Elongation Per Cent.	Resilience (Charpy Drop Weight).	Brinell Hardness Nos.	Grain of Shock Test Bar.
	deg.						
No. 2	450	—	—	—	2.40	416	Crystalline.
Copper and chromium, but no nickel	600	—	—	—	12.86	302	Fibrous.
	650	—	—	—	19.15	269	,,
No. 7	450	not recorded	158.0	7.0	9.10	387	Crystalline.
Chromium and nickel, but no copper	600	91.0	102.3	15.0	18.30	286	Fibrous.
	650	68.3	88.3	17.5	26.60	241	,,
No. 9.	450	not recorded	155.0	7.0	6.20	430	Crystalline.
Chromium, copper, and nickel	600	98.4	107.0	11.0	11.90	302	Fibrous.
	650	80.2	89.0	14.0	21.70	255	,,
No. 11.	450	149.0	164.1	5.0	2.40	418	Crystalline.
Chromium and nickel, but no copper	600	107.8	125.7	10.0	7.20	340	Crystalline and fibrous.
	650	91.7	109.0	13.0	15.60	302	Fibrous.
No. 12.	450	not recorded	166.2	4.0	4.30	431	Crystalline.
Chromium, copper, and nickel	600	104.2	112.4	10.5	18.30	302	Fibrous.
	650	—	—	—	25.80	269	,,
No. 13.	450	not recorded	130.9	7.0	13.80	340	Coarse crystals.
Chromium and nickel, but no copper	600	78.6	90.8	13.5	24.2	255	Fibrous.
	650	—	—	—	33.2	228	,,
No. 14.	450	132.3	134.6	7.0	9.1	340	Crystalline.
Chromium and copper, but no nickel	600	85.5	96.4	11.0	24.2	286	Fibrous.
	650	—	—	—	28.3	228	,,
No. 15.							
Chromium, copper, and nickel	200	not recorded	219.0	6.0	—	—	—

1. When, apparently, the percentage of nickel is below 5 per cent., steels containing above 4 per cent. of copper forge badly. Confining the observations to forgeable steels, it has been observed that copper, by itself, while slightly increasing the depth of penetration of the hardening effect, does not increase it sufficiently to confer on steels the property of air tempering, even when small parts, such as 10-mm. square bars, are concerned.

It is to be remarked that if the amount of nickel that could be introduced into the steel were limited to 4 per cent. the same conclusions would be reached.

2. In the presence of chromium the copper increases, fairly noticeably, the depth of the penetration of the hardening effect to the extent of rendering the employment of chromium-copper steels a matter of practical interest. (See Table II.)

It has only been upon steels containing both chromium and copper that the more extended experiments, of which an account is about to be given, have been made.

3. None of the chromium-copper steels prepared by the author possess the property of undergoing transformation (the γ to α transformation) at low temperatures, nor, therefore, that of hardening when the cooling is exceedingly slow, whereas chromium-nickel steels rather high in nickel (4 per cent. of nickel and 1.5 per cent. of chromium) possess this property. (See Table II.)

The addition of 4 per cent. of copper to a steel (No. 10) containing 2.52 per cent. of nickel and 1.59 per cent. of chromium does not likewise communicate to it the property of hardening on very slow cooling during annealing. (Table III.)

4. The addition of nickel to steels containing chromium and copper allows of the depth of the penetrative influence of quenching being increased, but only to the detriment of the property of softening by annealing. Having due regard to the size of the pieces and the use to which they are to be put, there is an advantage to be derived from the introduction of a more or less high proportion of nickel into steel.

5. The simultaneous addition of copper, nickel and chromium to a steel permits of the easy preparation of steels which possess a tendency to deep penetration of the hardening effect sufficiently marked to render the air-hardening of large enough pieces (for example, gearings) efficacious, without such steels losing the property of becoming softened by the orthodox annealing processes employed in the case of ordinary carbon steel. (Table III.)

These two properties, (*a*) depth of penetration of hardening effect, and (*b*) facility for softening on annealing, can be obtained amongst steels the composition of which may vary within fairly wide limits.

6. According to the tests carried out by the author the chromium-copper and chromium-nickel-copper steels possess, after hardening and tempering, practically the same mechanical properties (tensile and impact) as chromium-nickel steels having approximately the same carbon percentage and the same penetrative capacity for hardening (Table IV). It should, however, be pointed out that the chromium-copper steels assume, on quenching at somewhat low temperatures, a rather coarser grain on fracture than that exhibited by nickel-chromium steels; there is therefore more danger of their becoming burned.

Summary.—Copper increases the depth of the hardening effect in steels.

The influence of copper in the presence of chromium is marked. One per cent. of copper suffices to confer on steels containing 1.5 per cent. of chromium an interesting degree of capacity for sustaining the hardening effect in point of depth. The action of the copper is more limited than that of nickel. All the chromium-copper steels prepared by the author, containing less than 3 per cent. of nickel, soften on annealing at high temperatures, and consequently do not harden on quenching when the rate of cooling is very slow.

The simultaneous employment of copper, nickel and chromium allows of semi-hard steels being prepared which can be hardened by air-cooling on largish pieces and yet softened by the ordinary annealing methods used for carbon steels. The limits of chemical composition within which such steels should fall are wide enough to render their manufacture easy.

The chief influence of copper, like that, indeed, of other special elements, is to increase the depth of the penetrative influence of the quenching, and consequently the efficacy of heat treatment in the interior of the pieces

* Paper read before the Iron and Steel Institute, in London.

TABLE II.—*Influence of Copper on the Depth of Hardening in Chromium Steels not containing Nickel.*

Treatment.	Brinell Hardness Nos.			
	No. 1.	No. 2.	No. 3.	No. 4.
Cooled in still air from 790 deg. on square bars 10 mm. by 10 mm.	312	512	—	477
Cooled in still air from 790 deg. on square bars, 20 mm. by 20 mm.	241	364	—	—
Cooled in still air from 790 deg. on square bars, 30 mm. by 30 mm.	234	255	—	—
Cooled in still air in bundles of four bars, 30 mm. by 30 mm.	—	—	—	269
Cooled in still air at 820 deg. on square bars, 10 mm. by 10 mm.	340	555	—	477
Cooled in still air at 820 deg. on square bars, 20 mm. by 20 mm.	255	512	—	477
Cooled in still air at 820 deg. on square bars, 30 mm. by 30 mm.	261	255	—	302
Cooled in still air in bundles of four bars, 30 mm. by 30 mm.	—	—	—	269
Cooled in still air at 870 deg. on square bars, 10 mm. by 10 mm.	555	555	207	555
Cooled in still air at 870 deg. on square bars, 20 mm by 20 mm.	444	600	—	512
Cooled in still air at 870 deg. on square bars, 30 mm. by 30 mm.	321	600	—	512
Cooled in still air in bundles of four bars, 30 mm. by 30 mm	—	—	—	444
Annealed at 820 deg.	163	217	187	170

TABLE III.—*Influence of Copper on the Depth of Hardening in Chromium-Nickel Steels.*

Treatment.	Brinell Hardness Nos.					
	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Cooled in still air from 790 deg. in bundles of four bars, 30 mm. by 30 mm. square	269	321	387	340	418	477
Cooled in still air from 820 deg. in bundles of four bars, 30 mm. by 30 mm. square	286	321	418	402	477	512
Cooled in still air from 870 deg. in bundles of four bars, 30 mm. by 30 mm. square	321	350	444	444	477	477
Annealed at 820 deg. ..	179	207	269	207	207	196

subjected thereto. Apart from this influence on the depth of penetrative influence of quenching the author has failed to detect any other useful effect of copper on the properties of steel.

NOTE ON THE HARDENING OF STEELS CONTAINING HIGH PERCENTAGES OF CHROMIUM.

The special steels most commonly employed generally contain more nickel than chromium, because the somewhat violent action of chromium, which is liable to lead to cracks while quenching, is dreaded. The author conceives it useful to recall a few statements he made on a former occasion in this connection.*

The rate of cooling required to lower the transformation temperature in the neighbourhood of ordinary temperatures, that is to say, in order to produce hardening, varies within enormous limits. It is very difficult to ensure uniform cooling during quenching, even when all the factors acting on the rate of cooling are rigorously defined. It is similarly very difficult, when metals which require a rapid rate of cooling are treated, to ensure a uniform degree of hardening. If, on the contrary, metals which undergo energetic hardening on air-cooling are employed, it is obvious that when they are cooled in a liquid in which the cooling effect is more rapid the hardening will still be energetic and uniform, if the conditions of the cooling vary.

Steels containing at least 1.4 per cent. of chromium and a little copper or nickel are, in these circumstances, of a kind that can be quenched in a liquid between the temperature of 120 deg. and 350 deg. (real colza oil does well) without the energy of the cooling varying much, and in these circumstances there is not much fear of cracks developing.

Generally speaking, pieces of medium thickness (30 mm. or less) are susceptible of being so treated if made from air-hardening steels. Such metals soften very well on ordinary annealing, and after annealing are easy to machine. Naturally if it be desired that the hardening effect should penetrate to the core in very thick pieces, or if air-hardening is to be adopted, metals should be employed which have a greater susceptibility to the penetrative effect of hardening.

From Table II it will be seen that the chromium steels not containing copper (Nos. 1 and 3) harden only with difficulty on cooling in air. Steel No. 3, even when quenched in the form of bars 10 mm. square from a temperature of 870 deg., only possesses a hardness of 207 deg.

Before steel No. 1 attains distinct hardening in air-cooled bars of 10 and 20 mm. square section a temperature of 870 deg. has to be reached. With bars 30 mm. square air-quenching, even from 870 deg., is not very effectual.

On the other hand, steels Nos. 2 and 4, which contain

* "Hardening in Heated Liquids," *Bulletin de la Société de l'Industrie Minérale*, July, 1913.

copper and chromium, when in bars of 10 mm. section, become air-hardened when a temperature of 790 deg. has been reached. Square bars 20 mm. by 20 mm. air-harden after heating to 820 deg., and bars 30 mm. by 30 mm. harden in air after heating to 870 deg.

In the case of steel No. 4 it has even been established that, on heating to a temperature of 800 deg., bundles of even four bars, each 30 mm. by 300 mm. square, can be effectually air-hardened.

It will be seen that the presence of copper does not prevent softening on annealing at a high temperature.

From Table III it will be seen that the chromium-nickel steels not containing copper (Nos. 5 and 6), which soften well on annealing, do not possess the property, in thick pieces, of air-hardening.

Steel No. 7, containing chromium and nickel but no copper, air-hardens well but does not soften well on annealing.

Steels 8, 9 and 10, containing chromium, copper and nickel, air-harden even in thick pieces and soften well on annealing.

Steels Nos. 2, 7, 9, 11, 12, 13, and 14 were tested in bars 160 mm. long, cut from a forged bar of 30 mm. by 30 mm. square section. After treatment they were either notched for the resilience tests (the notch being a round one of 8 mm. diameter) or machined to round bars 13.8 mm. in diameter and 100 mm. long between punch marks, for the tensile tests. The elastic limit was determined roughly by observing the slowing down in the rate of the rise of the mercury column. The Brinell hardness was ascertained by means of a ball 10 mm. in diameter at a pressure of 3000 kg. and applied to the surface of the bars used for the shock tests. Both the shock and tensile test-pieces were quenched, from a temperature of 800 deg., in oil at about 50 deg. They were kept for about half an hour at the tempering temperature, after which they were quenched in cold oil.

As an exception the tensile test-piece of steel No. 15 was taken from a forged round of 20 mm. diameter. It was completely turned down, before testing, to a diameter of 13.8 mm. It was cut to 100 mm. length between punch marks and after machining was quenched from 800 deg. in oil at 150 deg. and tempered for one hour at 200 deg.

The tests shown in this table show the properties of steels containing copper to be practically the same, both on quenching and tempering, as those of steels not containing copper.

AMERICAN CONTRACTS FOR SUBMARINES AND DESTROYERS.—According to *The Iron Age* the Electrical Boat Company, New York, has been awarded contracts for 24 submarines on a cost plus 10 per cent. profit basis, the Navy Department agreeing to secure the necessary steel plates and shapes. The company's proposal offered to build these boats at 1,524,000 dols. if constructed on the Atlantic coast and 1,592,000 dols. if built on the Pacific coast. The department has also awarded a contract to the Lake Torpedo Boat Company, Bridgeport, Conn., for 4 boats at cost plus 10 per cent. Contracts for 10 of the 38 submarines for which proposals were received remained to be awarded when our contemporary was issued (May 24). Other bidders were the California Shipbuilding Company, Long Beach, Cal., which offered to construct boats on a cost plus profit basis, and Messrs. Schneider and Co., France, who proposed to license the Navy Department to build submarines on their patented designs for 65,000 dols. for the first vessel and 45,000 dols. for each succeeding one. The Newport News Shipbuilding and Dry Dock Company has been awarded an emergency contract for the construction of six torpedo-boat destroyers at approximately 1,250,000 dols. each. These will be paid for out of the special fund appropriated by Congress to enlarge the Navy and expedite the construction of warships, which was voted immediately after the declaration of war with Germany.

THE RESOURCES AND PRODUCTION OF IRON AND OTHER METALLIFEROUS ORES.—The Advisory Council for Scientific and Industrial Research has issued a report, prepared by Mr. G. C. Lloyd, secretary of the Iron and Steel Institute, summarising the latest information available regarding the iron ore resources of the United Kingdom and of other countries. The aim of the report has been to collect and present in a summarised form the main facts concerning the resources of iron ores and of other metalliferous ores accessory to the metallurgy of iron and steel, and to indicate their composition and character, giving as many analyses as possible of the minerals in every locality, with indications as to their geographical position and accessibility. The report is divided into three main parts, of which Part I deals with the iron ores of Great Britain and Ireland and of the British Dominions. Part II gives information of the same kind, and, as far as available, with regard to most of the other countries of Europe, Africa, Asia and North and South America. In Part III notes are given of the principal uses, occurrence and composition of the ores of metals other than iron but used in the iron industry, namely, chromite, cobalt, manganese, molybdenum, nickel, titanium, tungsten, vanadium and zirconium, including references to the composition of ferro-alloys manufactured from some of these ores. For the purposes of the report no new investigations of any special kind have been undertaken, but the most recent reports on the mineral deposits of the various countries have been briefly reviewed and, for the benefit of those who wish to make further search regarding them, references to the original sources of information have been given in every case. The report can be purchased at the price of 2*s.* net through any bookseller, or directly from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2.

GERMAN WAR PROFITS.

THE Hahn Tube Works, at Berlin and Grossenbaum, last year earned net profits amounting to 2,754,435 marks, against 1,445,258 marks for the previous year; the shareholders obtain a dividend of 16 per cent. and an additional bonus of 600,000 marks, or another 8 per cent. As the capital, however, is not fully paid-up, the dividend in reality amounts to 30 per cent.

The Rhenish Lignite and Briquette Company, Cologne, has a surplus for last year of 11,995,274 marks, against 7,605,567 marks for the previous year. Writings-off have risen from 2,532,717 marks in the previous year to 3,814,810 marks for last year, and the dividend has been fixed at 12 per cent., against 10 per cent. for the previous year.

The United Cologne-Rottweiler Powder Companies had during last year a turnover which exceeded the highest peace figure ten or twelve times. With the heavy writings-off and the cautious financial policy adopted by the concern, the dividend was restricted to 20 per cent.

The German chemical industry seems to be doing well on the whole; the Griesheim-Elektron Company, in Frankfort, has net profits for last year of 8,264,755 marks, against 4,610,977 marks for the previous year. A sum of 1,000,000 marks is added to the invalid fund and a workmen's pension fund has been formed, for which 2,000,000 marks have been set aside. The dividend has been fixed at 16 per cent., as for the preceding year, but with a bonus of 6 per cent.

The Friedrich Beyer Dye Works pay a dividend of 20 per cent. for last year and a bonus of 80 marks per share. The present year will not be worse than the preceding year, but serious difficulties may be looked for in the transition period from war to peace, and also afterwards, due to the foreign competition which is subsidised by Governments and backed up by large capitalists. Much good, however, is expected from the flourishing nitrogen industry, which is expected to develop into a large export business and be able successfully to compete against the Chili products.

The German Cast Steel and Machine Company at Schweinfurt pays a dividend of 25 per cent. for last year, and the Frankfort Machine Manufacturing Company 20 per cent., although a higher dividend was asked for. The company has so far reserved 3,200,000 marks for war profit taxation and 350,000 marks for alterations necessitated by the return of peace.

The Donnersmarck Hütte pays a dividend of 18 per cent. for last year, and the current year has so far been favourable. The German-Luxemburg Mining and Iron Works have not yet fixed the dividend for last year, but it is confidently stated that it will materially exceed, if not double, the previous year's dividend of 7 per cent.

The Georg van Gieseckes Erben Company, after writings-off, &c., shows profits of 22,800,000 marks. The dividend has been fixed at 1,800 marks per portion and an extra bonus of 300 marks in war loan; during the last years before the war the dividend was 1,600 marks per portion. This large concern is almost entirely in the possession of the family.

VAPOUR PRESSURES AT LOW TEMPERATURES.—In the course of experiments on the condensation and separation by fractional distillation of the constituents in natural oil—a research which we noticed some time ago—Messrs. G. A. Burrell and I. W. Robertson, of the Bureau of Mines (Technical Paper 142), also measured the vapour pressures of various compounds at low temperatures. The gas or vapour under test was confined in a glass bulb connected by a T with a manometer (U tube filled with pure mercury after Germann) and with a pump; the bulb was kept in a bath of gasoline, the latter being cooled by forcing more or less liquid air from a Henning thermostat (Reichsanstalt) through a double-walled tube into a wide tube immersed in the gasoline bath. Temperatures were measured by pentane thermometers, which proved more convenient than a platinum-resistance thermometer. The paper briefly describes the preparation of the pure compounds examined, ethylene, ethane, propane, propylene, butane, acetylene, ammonia, sulphur dioxide, nitrous oxide, and the calibration of the thermometers and apparatus. The gas pressures used ranged from 1 mm. or less up to 760 mm. of mercury, the temperature from 0 deg. down to −159.8 deg.; the agreement between the calculated (formula of Nernst) and observed vapour pressures was on the whole very good, and the ranges in many cases were wider than they had been in previous determinations. Plotting the pressure observed as ordinate against the rising temperature as abscissa, regular curves were obtained, while the curves of the logarithm of pressure as function of the reciprocal of the absolute temperature were straight lines. The following are some of the pressure minima in millimetres of Hg observed at the temperatures stated in brackets: Ethylene 4 (− 159.8), ethane 1 (− 159.8), acetylene 1 (− 143), isobutane 1 (− 114.8), ammonia 1 (− 113), propane 3 (− 124.2), propylene 3 (− 127.4), butane 1 (− 99.7), sulphur dioxide 0.5 (− 94.4), nitrous oxide 1 (− 144). The utility of such tables shows, for instance, in the separation of gas mixtures. Ethane has at its boiling-point, − 89.3 deg. C., the normal vapour pressure of 760 mm.; whilst the vapour pressure of propane at that temperature is only 68 mm, so that the ratio of the two vapour pressures is 11 : 1. At − 140 deg. C. the vapour pressures are: ethane, 18 mm.; propane, 0.5 mm. (calculated value); the ratio of this would be 36 : 1, and separation of the two vapours would be much easier, therefore, at − 140 than at − 89 deg. C. Analysis of a mixture of laughing gas N_2O with a little air and water vapour was made by condensing the water at − 78 deg. and then separating the air from the N_2O by the aid of liquid air.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on colonial and foreign engineering projects, taken from the Board of Trade Journal. Further particulars can be obtained from the Department of Commercial Intelligence, 73, Basinghall Street, London, E.C. 2.

South Africa.—H.M. Trade Commissioner in South Africa has forwarded a copy of the specifications, plans, and tender form in connection with a call for tenders by the Cape Town Corporation, as follows:—Sealed tenders, on the proper form, will be received by the Town Clerk, Town Hall, Cape Town, up to noon on July 31, for the construction of tanks and percolating beds for sewage disposal and other works in connection therewith, being Contract No. 7 of the main drainage scheme, southern suburbs, Cape Town.

Republic of Colombia.—*The Diario Oficial*, Bogotá, publishes a resolution authorising the municipal council of Zipaquirá to contract a loan of 24,000 pesos (4,800*l.*), to be devoted to the construction of an aqueduct and a series of culverts at that town, which is in the Department of Cundinamarca.

FERRO-CONCRETE RETAINING WALL FOR A COAL YARD.—The new coal yard, of 24,000 tons capacity, of the gas works at Karlsruhe is bordered on its southern side by a wall of ferro-concrete, 160 m. in length, 3 m. high, which supports the rail track and platforms of the coal-distribution plant. The structure, which is illustrated in the *Oesterr. Wochenschrift für den Öffentlichen Baudienst* of January 11, 1917, is interesting in so far as the wall has been constructed as a continuous ferro-concrete girder, anchored at distances of 16 m. to piers of rammed-down concrete. The article by Franz Knapp, to which we refer, deals also with the calculations which the construction involved.

STATE-SUBSIDISED STEEL PRODUCTION IN NORWAY.—For some time means have been discussed for increasing Norway's production of iron and steel, so as to make the country more independent of foreign supplies, a shortage of which might prove a most serious matter, not only for the Norwegian industry, but also, and even more so, from a military point of view. The Strömmen works will receive a subsidy of 51,200 kroner, so as to be able to increase their production of steel from 5,000 tons to 10,000 tons per annum. In order further to increase the Norwegian production of steel from 12,000 tons to 24,000 tons and to put down a rolling mill having a minimum annual production of 10,000 tons of rolled products, the Christiania Spikerverk is to receive, for a period of five years, a premium of 8 kroner per ton of rolled steel made. The new installations at the Strömmen works are not supposed to commence operations until war mobilisation takes place, and the steel to be produced there will be ingots for projectiles, &c. The Christiania Spikerverk, on the other hand, is to start under the new scheme in peace time only, and its rolled products are to be mainly for use in ferro-concrete work.

INDUSTRIAL RESEARCH IN THE UNITED STATES.—Amongst the companies which undertake research in the United States on an extensive scale are many whose products are well known in this country. For example, the Eastman Kodak Company spends on research about 30,000*l.*, or 0.7 per cent. of the company's profits, per annum; the General Electric Company from 80,000*l.* to 100,000*l.* per annum. A most striking feature of the research work undertaken by such firms is the installation in many cases of full-scale manufacturing facilities, which on the one hand enable processes to be perfected and the works to be relieved of the hampering effects of experimental developments, and on the other hand give the laboratory staff some elementary practical introduction to the complexities of actual manufacture as contrasted with the relative simplicity of laboratory preparation. Other noteworthy facts are the freedom with which results in pure science are published; the growing appreciation in the factory of the commercial value of scientific men; and the recognition of the value of research laboratories as a means of inspiring confidence in the minds of customers. There are a number of associations of manufacturers which undertake research work for the common benefit of their members. In some instances the work is carried out in laboratories connected with individual manufacturers, in universities, or at the Bureau of Standards. Some associations, for example, the National Canners' Association, possess their own research laboratories. The national institutions which deal with industrial research are lavishly financed either by the State or by private benefaction. Most excellent means for publishing their results have been developed; they offer extensive facilities to industry for research; and their advice is freely given. The work done by such institutions as the Bureau of Standards, the Carnegie Institution, the Forest Products Laboratory, and the Bureau of Mines is well known in this country. The commercial research societies are on an extensive scale and are well equipped. The scientific societies, in addition to offering channels, in their journals, for the publication of research results, are also in some instances interested in, or are in control of, endowment funds for research work. All these facts, and many more, are set forth in a pamphlet by Mr. A. P. M. Fleming, M.I.E.E., which is the first of a series which the Advisory Council of Scientific and Industrial Research intend to issue. It is to be purchased through any bookseller or direct from H.M. Stationery Office, Imperial House, Kingsway London, W.C. 2, price 1*s.* net, or 1*s.* 3*d.* post free.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

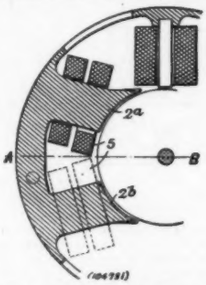
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

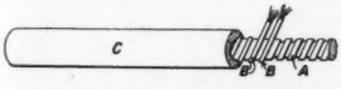
ELECTRICAL APPARATUS.

104,731. J. H. St. Mawdsley, Dursley, and H. F. Joel, the Senior, Forest Gate. Dynamo Electric Machinery. (2 *Figs.*) March 15, 1916.—This invention relates to dynamo electric machines of the type described in the Specification of Letters Patent No. 15478/08, in which only one interpole is provided with each pair of main poles, and in which the main magnetic flux almost entirely passes through the portion of the yoke between two adjacent main poles. In machines of this type the pair of main poles are of U-formation, the limbs forming



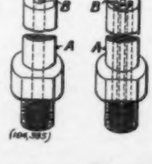
the two poles being parallel one to the other. In dynamo electric machines, in accordance with this invention, the poles 2a, 2b of each pair of main poles are arranged, as usual, symmetrically about the centre line A—B between them, but instead of the poles being parallel one to the other as above described, they are inclined one to the other in suchwise that the faces of the magnetising or field coils 5, which extend in a direction at right angles to the axes of the poles, shall be at right angles, or approximately so, to a line drawn through the centre of the armature and approximately midway between the centre line A—B and the adjacent edge of the pole. (*Sealed.*)

104,401. British Insulated and Helsby Cables, Limited, and E. A. Bayles, Helsby. Electric Cables. (2 *Figs.*) March 17, 1916.—According to the present invention, a vulcanising rubber core A is employed, and the cable is constructed by winding the insulated or uninsulated conductor or conductors B, B¹, on this central core of vulcanising rubber, which may be solid or hollow, then forming on the said core a sheathing C of vulcanising rubber of suitable thickness, and afterwards vulcanising the core A and sheathing C together to form a continuous cable in which the spirally disposed conductors B, B¹, are firmly embedded between the core and the sheathing and effectually



insulated. Such a cable will sustain a considerable load in tension, and, being elastic, will stretch in accordance with the load without subjecting the conductors to stress. As the cable stretches under load without materially stretching the conductors B, B¹, it is well adapted for use in such cases as trailing cables, flexible connections to portable appliances and the like applications, in which at present the usual types of flexible conductor is used and found to give unsatisfactory results, chiefly because the cable is inelastic and because any tensile stress applied strains the conductors and ultimately fractures them. (*Sealed.*)

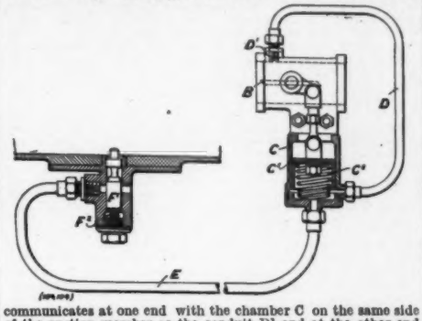
104,385. Marconi's Wireless Telegraph Company, Limited, and H. M. Dowsett, London. Wireless Telegraphy. (2 *Figs.*) March 2, 1916.—This invention relates to the studs or electrodes of electric dischargers used in the production of electric oscillations, and especially to the rotary or disc dischargers used in wireless telegraphy. According to this invention, the studs are formed of two different materials, one of which is vaporised at a lower temperature than the other.



Preferably each stud consists of a sheath of metal, copper for example, enclosing a core of less refractory and less conductive metal, aluminium for example, or it may be of carbon or other suitable material. Fig. 1 shows a stud A formed of copper and having a single core B formed of aluminium, Figs. 2 shows a stud in which there is a multiple core, which is found to vaporise slower than a single core of the same total section. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

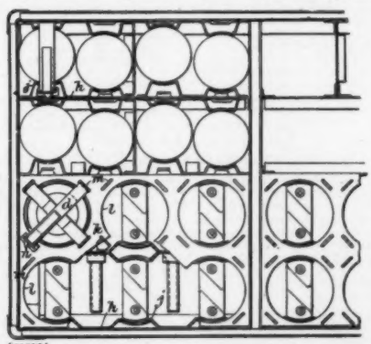
104,104. W. H. Dorman and Co., Limited, and O. W. J. Watson Stafford. Internal-Combustion Engines. (1 *Fig.*) June 29, 1916.—This invention relates to governors for internal-combustion engines and to the type of governor in which the engine-throttle is connected to a suction member controlled by the suction of the engine and counter-controlled by a centrifugal governing device which either renders the suction of the engine on the suction member ineffectual or in some cases reverses its operation. According to this invention, a governor of the type described has combined with a suction chamber C and a yieldingly controlled suction member (for example, a piston C¹) therein, a conduit D which communicates at one end with the chamber on one side of the piston C¹ and at the other end with the suction side of the engine inlet pipe D¹, and a second conduit E which



communicates at one end with the chamber C on the same side of the suction member as the conduit D¹ and at the other end with the governor-controlled valve F¹ for admitting atmospheric pressure, for the purpose of releasing the piston C¹, so that it can be moved upward by its yielding control (spring C²) when the governor is moved towards the throttling position. This upward movement will swing the butterfly-valve B towards the closing position, and as soon as the necessary control has been effected the governor will again allow the valve F¹ to rise under the action of its spring F², so that the pipe E will once more be cut off from communication with the atmosphere and suction will be again established within the chamber C. The piston C¹ will then once more be drawn down against the action of its spring C² and the throttle will be opened as shown in the drawing. (*Sealed.*)

GUNS AND EXPLOSIVES.

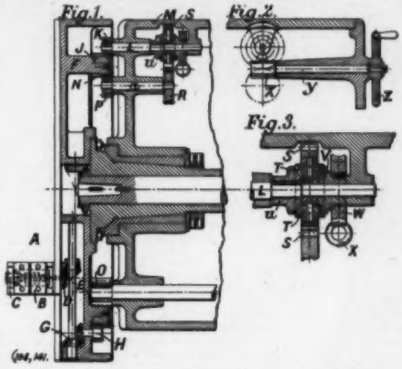
103,926. E. Squires, and the Metropolitan Carriage, Wagon and Finance Company, Limited, Saltley, Birmingham. Ammunition Wagons. (3 *Figs.*) May 19, 1916.—This invention comprises improvements in ammunition wagons and limbers, and has for its object to simplify the internal box portions or compartments which receive the ammunition. The characteristic features of this invention are the pressing of two or more hollow seating projections for shells or charge cases in one plate, and the provision of an end-plate for the shell compartments with shell apertures stamped therein and with slots or strap openings disposed around such apertures. In accordance with this invention, the seats for the shells or cases are formed as plates A in which projections *j* are raised by pressing or stamping operations, one plate providing at least two shaped projecting seats *j*. The seating projections may be pressed of equal height, if the cases or shells are to be arranged side by side, as shown in the lower part of the figure, or with one higher than the other if the cases or shells are to be nested or slightly staggered, as shown in the upper half of the figure. Pressed plates are provided to form the end-plate of a number of shell compartments,



circular apertures *l* being stamped in the plate to admit the shells and slots *m* being stamped at four equidistant points from the centre of each aperture and in a direction tangential to the perimeter of each aperture, but positioned slightly away from the said perimeter. These slots *m* form the strap-receiving parts, which are thus formed in the construction of the one plate member for a number of compartments instead of many little parts, and by this means they can be accurately positioned. In one slot of each set surrounding a shell aperture *l* a staple *n* may be secured projecting through the slot to receive the loop of the strap *d* and also the locking tongue. These pressed end-plates may be stiffened by pressing a rib or groove in the metal *k* between the shell apertures *l*, or separate channel or other stiffeners may be secured to the plate, and the vertical divisions between compartments are not then required. Each end-plate may serve for a number of shell apertures, say, six or more. Preferably the plate is flanged at top and bottom to form riveting flanges, so that it may be secured to the wall of the box part of the wagon or limber, and to which flanges the pressed plates A carrying the seating projections *j* may be riveted. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

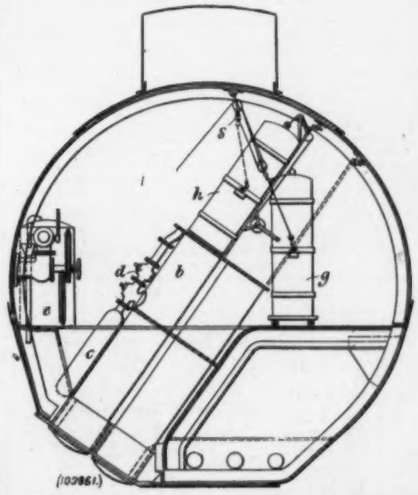
104,141. Wm. Muir and Co., Limited, J. H. Melloy, and W. Owen, Manchester. Machine Tools. (4 *Figs.*) October 28, 1916.—This invention relates to boring, milling, surfacing and tapping machines of the type in which a face plate is carried on a main spindle, this face plate carrying a tool slide which is provided with an automatic feed towards and from the centre of rotation. The improvements consist essentially in the application to the face plate F and facing or tool slide A of a hand-controlled adjustment for the tool towards or from the work longitudinally (distinct from and in addition to the usual movement of the facing or tool slide laterally to or from the axis of rotation) to enable the cut to be put on or taken off whether the face plate with the tool slide is rotating or stationary. The tool or facing slide A carries an auxiliary tool slide B arranged to travel in a direction towards or from the work; this auxiliary slide B is under the control of the screw C, on the end of which is a mitre wheel D gearing with a similar mitre on the shaft E carried in the rotary face plate F. Near the periphery of the face plate F is another pair of mitres G driven by a pinion H in



gear with a wheel J, mounted loosely on the face plate F, concentrically with it and controlled by a wheel K carried on a shaft L mounted in the body of the casting M. The face plate F is driven in the usual way by means of a pinion O gearing with an internal wheel N. In gear with this wheel N is a second pinion P carried on a shaft *a*, on the other end of which is a spur wheel R which drives another spur wheel S carrying the differential gears T, which gear with a mitre wheel U on the shaft L. On the opposite side of the differential gears T and meshing with them is another gear V, mounted loosely upon the shaft L and keyed to a worm wheel W. This worm wheel W is under the control of a worm X carried on a shaft Y mounted on the cover of the main casting M, and on the end of the shaft Y is fixed a hand wheel Z mounted in any suitable position on the machine convenient to the attendant. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

103,861. E. L. Peacock, and Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne. Submarines. (5 *Figs.*) February 15, 1916.—This invention relates to submarines, and especially to means for laying mines. According to this invention, means are provided for ejecting mines by compressed air, and means are provided for preventing the escape of air from the mine tubes after firing. *a* is the shell of the submarine, *b*, *b* are mine tubes, *c* is an air flask, *d* is the firing valve, *e*, *e* are compensating tanks, *g*, *h* are mines. In opera-



tion, the mine is raised from the position *g* to the position A by the tackle *s*. The air flasks *c* are of sufficient capacity and are charged with air at a pressure to eject the mine or mines clear of the ship without air passing out of the tube. The tubes, after ejection of a mine or mines, can be vented into the boat so that in either case air will not rise to the surface to give indication of mine-laying to the enemy. In case of slight excess pressure in the boat the air compressor can be used to reduce same to normal. (*Sealed.*)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

103,867. The Hon. Sir C. A. Parsons, S. S. Cook and L. M. Douglas, Wallsend-on-Tyne. Thrust Bearings. (6 *Figs.*) February 16, 1916.—The present invention relates to the lubrication of thrust bearings of the type in which a plurality of collars are provided on the rotating member, these collars bearing against stationary collars, and this invention relates more particularly to thrust bearings of this type in which fresh lubricant is fed through radial ducts in the stationary collars to the annular spaces between the roots of adjacent revolving collars and the inner peripheries of the stationary collars. The invention consists in providing two sets of gutters *h* in the working faces of the stationary collars *a*, the two sets

being oppositely inclined and extending completely across the working face, so as to provide clear passages, through which, when rotation takes place in either direction, lubricant admitted to the roots of the revolving collars *b* can flow outward to outlets at the roots of the stationary collars *a*. The invention further consists in providing at the inner periphery of each stationary

Fig. 1.

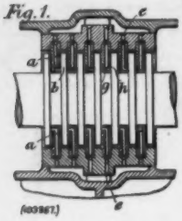
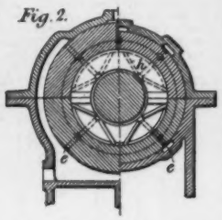
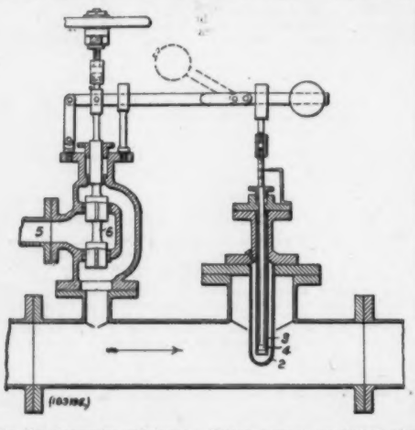


Fig. 2.



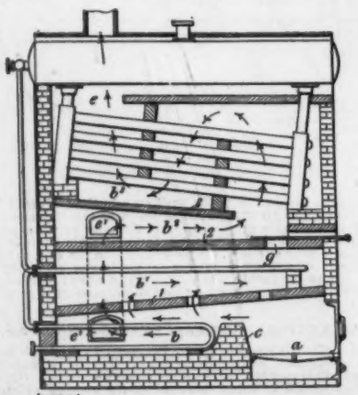
collar *a* recesses *w*, with each of which the inner ends of a radial inlet duct *e* and a pair of oppositely inclined gutters A communicate, the outer ends of the inclined gutters being arranged to freely discharge lubricant received from the inlet duct beyond the periphery of the adjacent revolving collar. (*Sealed.*)

103,196. P. A. W. Parkyn, Westminster. Superheaters. (2 *Figs.*) February 16, 1916.—The invention consists in the combination with the main connecting the superheater with the engine or other device in which the superheated steam is utilised and a valve-controlled by-pass in connection with the source of saturated steam of a thermostatic device comprising an outer tube 2 containing mercury or other expansive substance, an inner tube 3 in communication at its lower end with the expansive substance, and a piston or float 4 within the inner tube, the said piston or float being connected with the valve 6 of the valve-controlled by-pass, and being acted upon



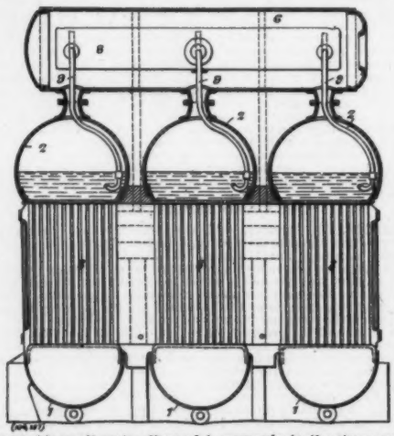
by the expansive substance. Under normal conditions the valve 6 remains closed, but if for any reason the temperature of the superheated steam main rises above a predetermined limit, the expansion of the mercury in the tube 2 causes the piston or float 4 to rise and open the valve 6 to admit saturated steam from the main 5 to the superheated steam main. As the saturated steam admitted to the superheated steam reduces the temperature of the steam in that main, so also does the mercury in the tube 2 contract and allow the piston or float 4 and valve 6 to return their normal positions. When the superheated steam main attains its normal temperature the valve 6 is again completely closed so as to cut off the supply of saturated steam. (*Sealed.*)

103,854. E. Peckham, Westminster. Furnaces. (7 *Figs.*) February 10, 1916.—This invention relates to furnaces for supplying heat to steam boilers or generators of the kind where the products of combustion are more completely converted into



gas by being brought into contact with or passed through fire-brick chambers which become highly heated and are hereafter referred to as gasifying chambers, whereby the resulting products contain little or no non-gaseous constituent when they are brought into contact with the boiler or generator. According to this invention, a plurality of superposed horizontal tapered flues constructed or lined with refractory material are employed, and the said flues are so tapered as to be constricted towards their outlet or where they lead into an adjacent or continuing flue, thereby restricting the flow of the products of combustion, which are being highly heated or gasified therein prior to being brought into contact with the boiler or generator or the like. The invention is limited to horizontal flues and does not include flues which are inclined downwards. *a* is a fire grate and *b* is a horizontal firebrick combustion chamber in the rear of the fire grate, and preferably separated therefrom by a bridge wall *c*. Over the combustion chamber *b* are horizontal firebrick chambers b^1, b^2 and b^3, which are formed by the horizontal firebrick arches 1, 2 and 3, separating the chambers. The chamber b^3 may be formed with closed ends as shown or with rear end open. The terminal gasifying chamber b^2 is tapered or constricted towards the outlet end. In the construction illustrated both ends of the firebrick chamber b^1 are closed, and the flame or gas passes upwards mainly through the upright flues e^1 in the sides of the furnace walls, and partly through openings in the top of the fire-brick arch 1, and through an opening *g* in the firebrick arch 2. The gas passes upwards through and around the chamber b^1 to the constricted chamber b^2 and from b^2 to the chamber b^3, in which the tubes are located, and passes around the tubes as shown on its way to the flue *e* leading to the stack. (*Accepted February* 21, 1917.)

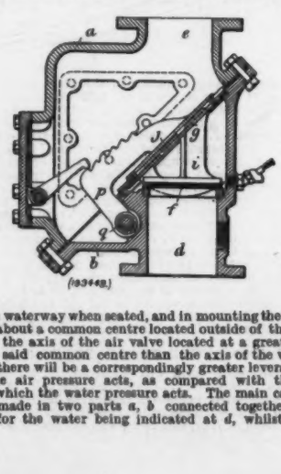
104,137. James Howden and Co., Limited, and J. H. Hume, Glasgow. Steam Generators. (2 *Figs.*) September 21, 1916.—This invention relates to multi-sectional steam generators. The invention consists in the provision in such generators of a feed-water heater and distributor also designed to serve as a deposit catcher, of the type comprising a receptacle located within the steam space and provided with an inlet connection and outlet branches; the receptacle being, according to the present improvement, located within the steam-collecting drum and fitted with branch pipes leading to the several upper drums of the generator. As shown, the generator proper comprises lower water drums 1 connected to upper water and steam drums 2 by upright tubes 3. 6 denotes a steam-collecting



drum of large diameter disposed transversely to the steam and water drums 2 coupled thereto. Accommodated within the drum 6 is a water container 8, disposed to one side of the axis of the drum and secured to the drum shell, preferably about midway of its length, where it has a valved connection to the feed-water supply. Led from the upper part of the container 8 to the steam and water drums 2 are branch pipes 9, each of which terminates below the water-level in the drum 2. As is evident, the arrangement is such that the water from the container 8 will be distributed evenly to the drums 2. The container 8 also functions as a surface heater for the feed water, it being understood that water condensing on its outer surface will be free to pass to the steam and water drums 2. If desired, the container 8 may be traversed by one or more tubes to afford increased heating surface. (*Sealed.*)

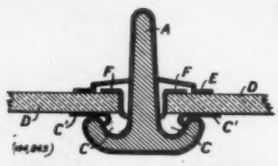
MISCELLANEOUS.

103,449. Mather and Platt, Limited, Manchester (*A. J. Loepsinger, Providence, U.S.A.*). **Sprinkler Installations.** (5 *Figs.*) September 9, 1916.—This invention relates to dry pipe valves for automatic sprinkler systems of that type provided with a water valve and an air valve located in a casing common to them, the valve being kept closed by the air acting upon the air valve at a pressure materially less than the pressure of water in the supply pipe. The invention consists primarily in so arranging the air valve and the water valve that each of them



closes the waterway when seated, and in mounting the said valves to swing about a common centre located outside of the waterway and with the axis of the air valve located at a greater distance from the said common centre than the axis of the water valve, whereby there will be a correspondingly greater leverage through which the air pressure acts, as compared with the leverage through which the water pressure acts. The main casing of the valve is made in two parts *a*, *b* connected together, the inlet opening for the water being indicated at *d*, whilst the outlet opening communicating with the riser of the sprinkler system is shown at *e*, the water valve *f* and air valve *g* being located between the two. The valves *f* and *g* have their seatings arranged in planes at an acute angle to each other. The water valve *f* is smaller in diameter than the air valve *g* and seats upon the seat ring, the valve face being carried by a suitably constructed stem *i* provided with an inclined face *j*, against which a flexible valve ring rests, such ring being clamped to face *j*. The flexible ring seats on the seat ring in the main casing *a*, and by reason of its flexibility allows both valves to engage their seats properly. The air valve is larger in diameter than the water valve, and consequently a pressure of air less than the pressure of the water enables both valves to remain seated under normal conditions. Both valves are carried from a pivotal centre common to them both and outside the waterway, and so that the axis of the air valve is at a greater distance from such centre than the axis of the water valve, thereby obtaining differential leverage conjointly with differential areas. To this end a bent valve arm *p*, pivoted on a centre *q* below the valve and connected at its upper end to the face *j* of the air valve, is employed. In addition to the mechanical advantages referred to, this arrangement serves to reduce the space required for the valves to swing in, thereby correspondingly reducing the size of the valve casing. (*Sealed.*)

104,843. F. W. Mellowes and H. Foulston, Sheffield. Glazing. (1 *Fig.*) November 9, 1916.—This invention relates to glazing of that type in which sheathed glazing bars support the glass by means of side gutters and the glass is held in place by means of two flanges of the sheath on each side of the bar, which flanges are rubbed on to the upper surface of the glass to provide weathertight joints. The bar A is provided with a sheath or covering of comparatively incorrodible and flexible material, such as lead, and is shaped to provide a gutter C upon each of its sides, a flange C^1 extending from each of these gutters to act as supports for the glass D. For holding the glass in place and to provide the necessary weathertight joints, the sheath is formed



with two pairs of flanges E and F. Of these flanges, the lower pair F springs from the glazing bar at about the level of the lower surface of the glass D, each flange F being bent over the upper edge of the glass and rubbed down on its surface as shown. The upper pair of flanges E springs from the glazing bar at a higher level than the upper surface of the glass, and each flange E is rubbed down on to the glass out of contact with the lower flange F, whereby an air space is provided between the flanges E and F, the effect of which is to increase the protection of the cushioning flanges F by reducing radiation and conduction of heat to the flanges F, whereby the tendency of the sun's rays to cause them to leave the glass is minimised. (*Sealed.*)

104,386. Marconi's Wireless Telegraph Company, Limited, and H. M. Dowsett, London. Aeroplanes. (2 *Figs.*) March 2, 1916.—In wireless telegraph working on aeroplanes there is a recognised difficulty that the metal work available to serve as the balancing capacity is limited, especially in the case of monoplanes. According to this invention, the internal bracing wires of the aeroplane wing are connected up together by arranging between the separate wires, where necessary, conducting joints, so as to provide a good path throughout the whole length of the wing, while the connected wires are in turn connected to the wireless transmitter. The electrostatic capacity may also be increased, without increasing the air friction, by mounting inside the wings additional wires which are electrically connected to the bracing wires and are supported by lashings through slots in the ribs or by other suitable means. These

Fig. 1.

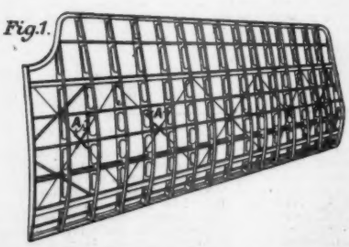
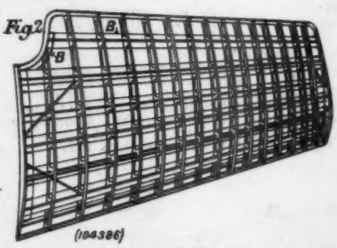


Fig. 2.



wires preferably form a grid, and may be either bare or insulated, single or multiple strand, and are preferably parallel and of equal length. Where the wires leave the wings, passing through the ribs and framework, and are exposed to the weather, they should be effectually insulated therefrom; but this insulation is less essential inside the wings, though preferable where practicable, for the prevention of loss through leakage. Fig. 1 is a perspective view of the framework of a wing provided with internal bracing wires A, which may be either bare or insulated, but in the former case they should not be in contact with the wing fabric. Good conducting joints are made between the separate wires where necessary, so as to provide a good conducting path the whole length of the wing. Fig. 2 shows a modification having a grid of wires B supported by lashings through slots in the ribs of the wing. (*Sealed.*)